3-16 September 1976 First and Third Friday Volume 142 Number 3544 30p

Model Engineer

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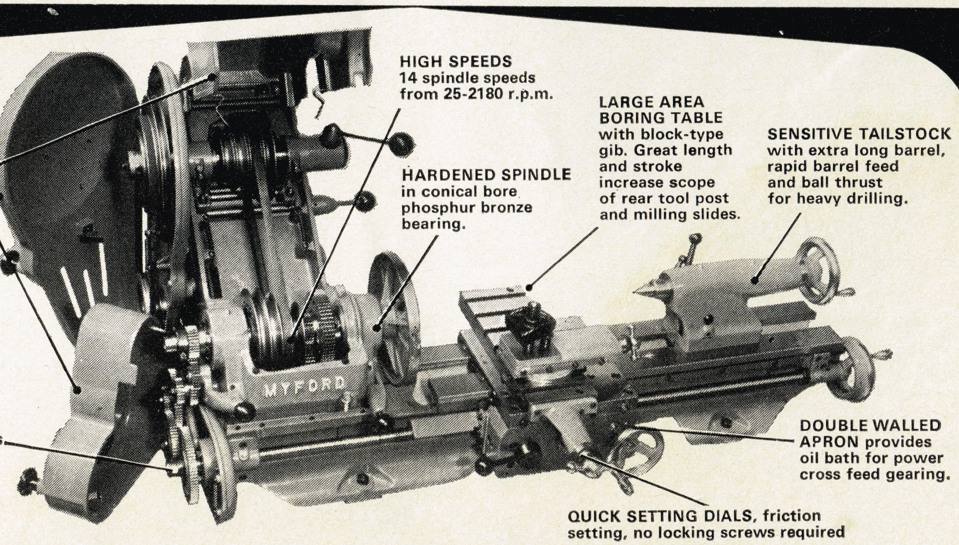

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Volume 142 Number 3544

3 September 1976

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COVER PICTURE

Some of the $7\frac{1}{4}$ in. gauge locomotives at a meeting at Stoneleigh. Colour photograph by W. J. Milner.

NEXT ISSUE

The Guildford Rally.
The valve gear for "Southern Belle", the new gauge 1 locomotive.

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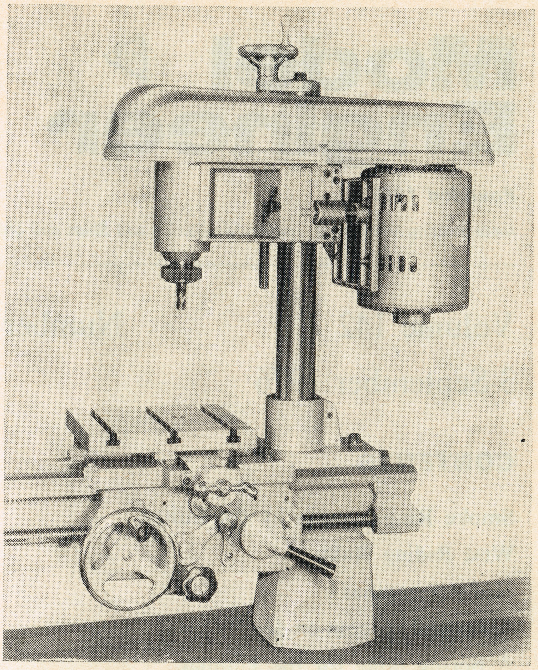

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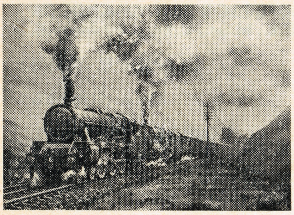

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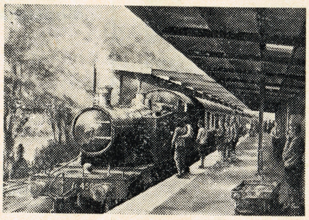

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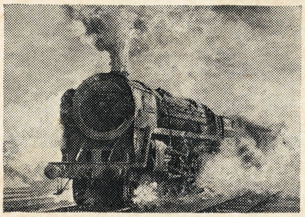

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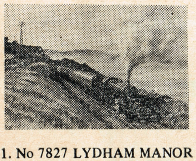

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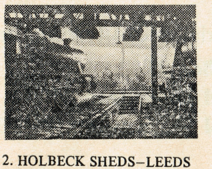
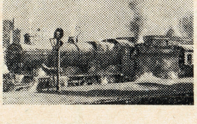


2. HOLBECK SHEDS–LEEDS
A Jubilee 4-6-0 and a Duchess 4-6-2 are shown in the foreground. A rebuilt Royal Scot 4-6-0 in the background. All executed in perfect detail by Geoff Shaw.



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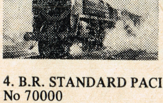

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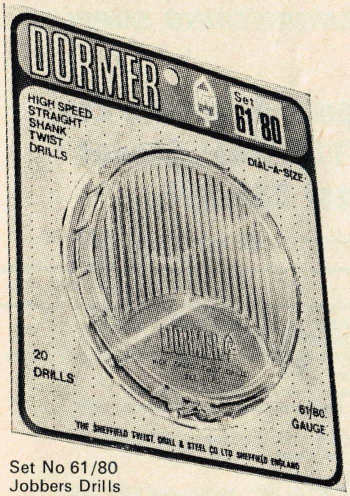
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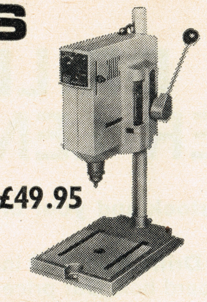

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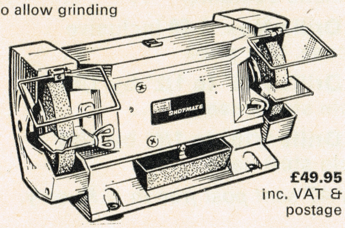

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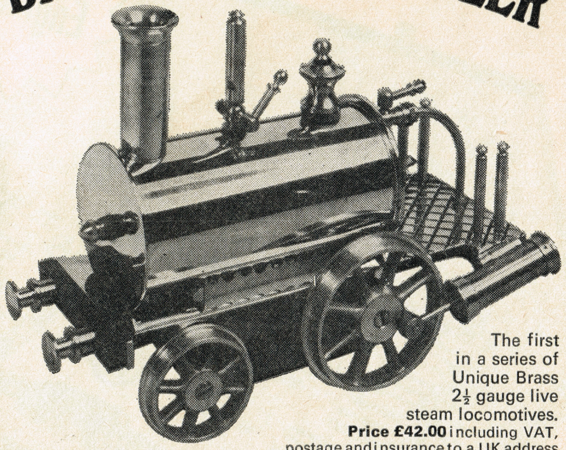

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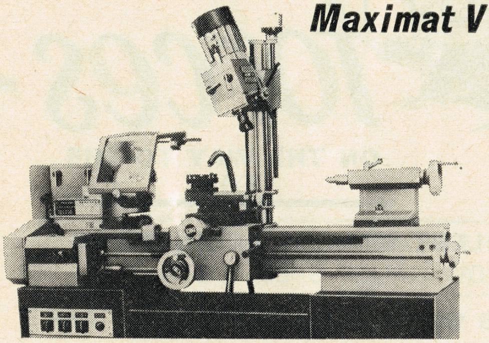

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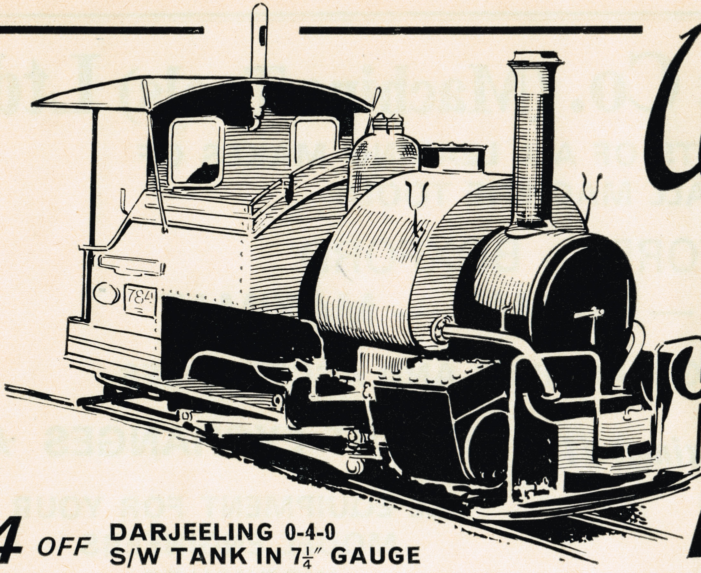

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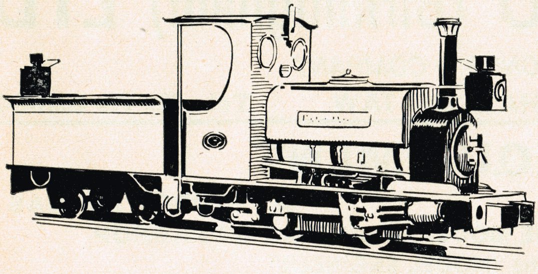

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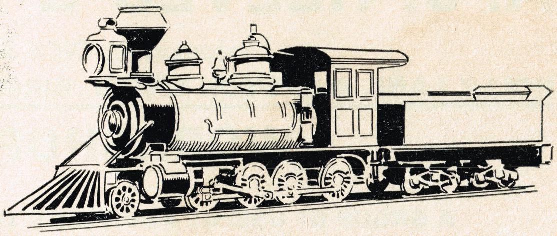

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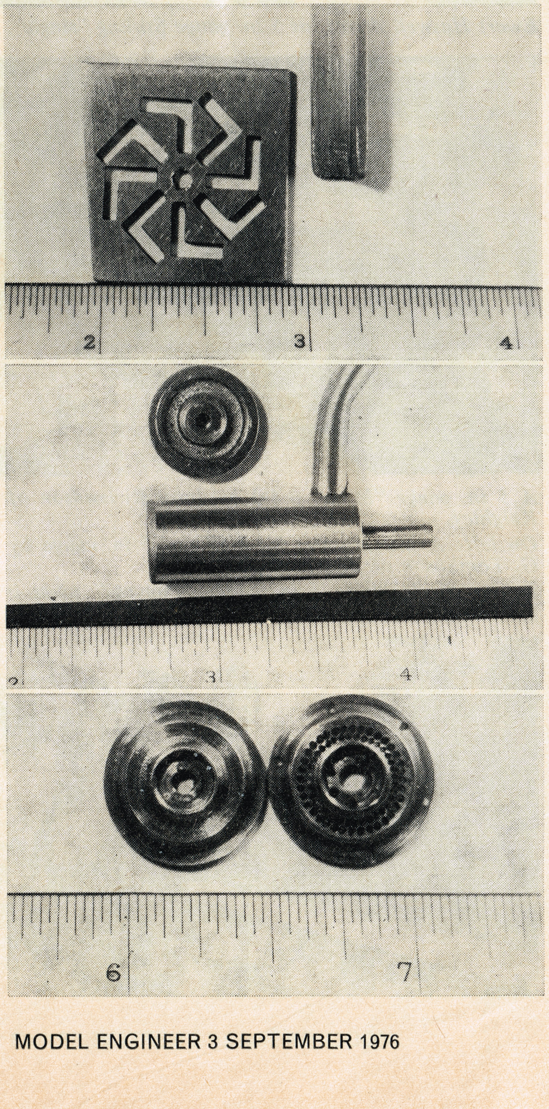
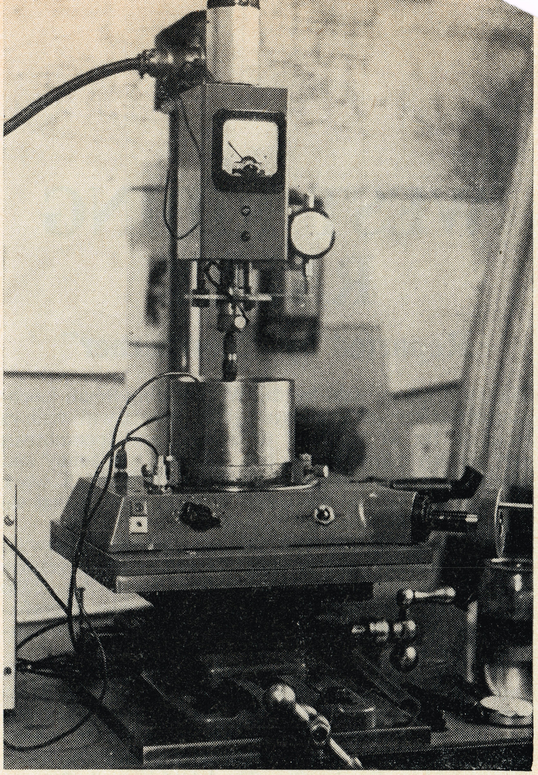
A Commentary by the Editor

Wheel and Track Standards

An error occurred in the table of wheel and track standards published on page 454 of our 7 May issue, which I think is of sufficient importance to be mentioned here. In the table for 2½ in. gauge, the figure for flange-way (F in the drawing) is given as 0.093 in. (2.3 mm), This should be 0.125 in. (3.2 mm.) otherwise this restricted flange-way could cause trouble for anyone building a ground level track for 2½ in. gauge.





A spark erosion machine made by Mr. E. Griffiths of Bristol. The meter reads head travel and the dial gauge gives a fine reading.

Left: A brass test piece (top), a recess cut and the electrode used—work stainless steel, electrode brass, machining time 4 hours (middle). A safety valve cover with 72 holes drilled separately. Inner row—.017 in. electrode. Outer row—.021 in. electrode. Holes approx. .003 in. larger than electrode (bottom picture).

News from Didcot

The Great Western Society's "Hall" class locomotive *Hinderton Hall* made its first main line run on 4 May when it ran from Didcot to Swindon for weighing after overhaul, in preparation for the third G.W. Society Vintage Train Railtour.

Work is now in hand on the restoration of "Castle" class locomotive No. 5051 *Earl Bathurst*. The boiler was lifted off the frames by the Didcot 50 ton hoist and was lowered onto a Crocodile F wagon for replacement of tubes and firebox stays. The frames were then lifted for removal of the driving wheels which are to be sent to Swindon for re-turning; the axleboxes will also be re-metalled there. Two other engines have arrived at Didcot recently—2-8-0 No. 3822, and another "Castle" No. 5029 *Nunney Castle*. Work is also continuing on 0-6-0 pannier tank No. 3738, which has undergone steam tests and will be running before long.

Ilford Exhibition

The Ilford & West Essex Model Railway Club is again holding its annual exhibition at Ilford Town Hall, the dates being 27—30 October inclusive.

Continued on page 843

WEST RIDING RALLY

Reported by "Northerner"

THE 1976 RALLY held by the West Riding Small Locomotive Society was as always a great success, with visitors from as far as Scotland to Surrey, and locomotives representing many regions too. The day was sunny and warm, there was a first-class display of W.R.S.L.S. work in the marquee, and the ladies' catering was all that we have learned to expect at Blackgates.

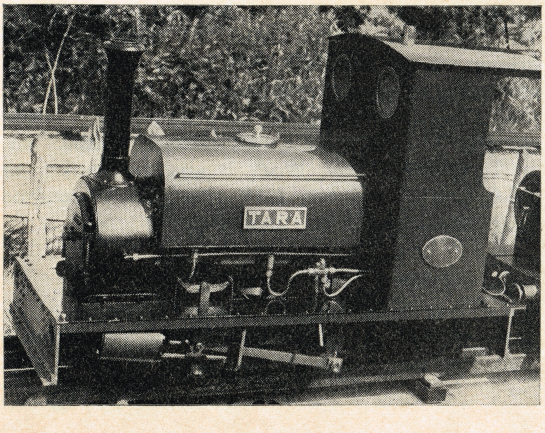
By coincidence, the first two locomotives we saw in the steaming bays were a 3½ in. and a 5 in. gauge version of the same prototype—the L.N.E.R. Pacific No. 2750 *Papyrus*. Both of these were excellent examples of craftsmanship, and when working on the track both were first-class runners.

The ¾ in. scale engine had been built by G. Nichols over a period of nine years "on and off" and was completed about a year ago. The larger scale version was built by our old friend Ted Holden of Blackburn, whose Aspinall "Atlantic" is a Northern classic and who has a very nice 3½ in. *Evening Star*. The 1 1/16 in. scale *Papyrus* started out as the Clarkson design, but was altered to incorporate piston valves and was then finished off using official L.N.E.R. drawings.

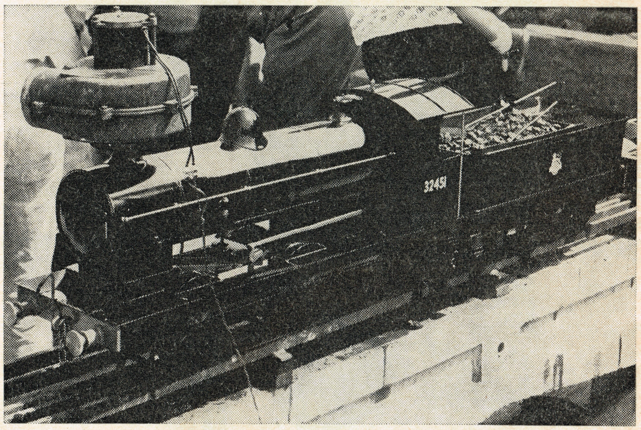
Ewart Haswell of Leeds has a nice Mikado *Cock o' the North* which is well-known especially on Northern tracks, but this time he had brought to Blackgates his four-year-old 5 in. gauge Stirling "Single". This is built to works drawings and, like the prototype No. 34, is fitted with balanced slide valves with the exhaust coming through the back. The engine runs beautifully, and with those huge drivers the connecting rods appear to be turning quite lazily even when the locomotive is running fast.

Two favourite "L.B.S.C." designs are *Minx* and *Maisie*, the former an inside cylindered 0-6-0 goods tender engine in 5 in. gauge and the latter the large-boilered Ivatt "Atlantic" in 3½ in. gauge. Here was a good example of each with the 0-6-0 by John Richardson of Keighley, who called it a "straightforward Minx", and the "Atlantic" built by John Walters of Retford basically to the words and music too. The *Minx* has been running about three years and *Maisie* about seven.

Two handsome 4-4-0's in 5 in. gauge were the relatively modern L.N.E.R. "Shire" class *Yorkshire*, and a L.S.W.R.



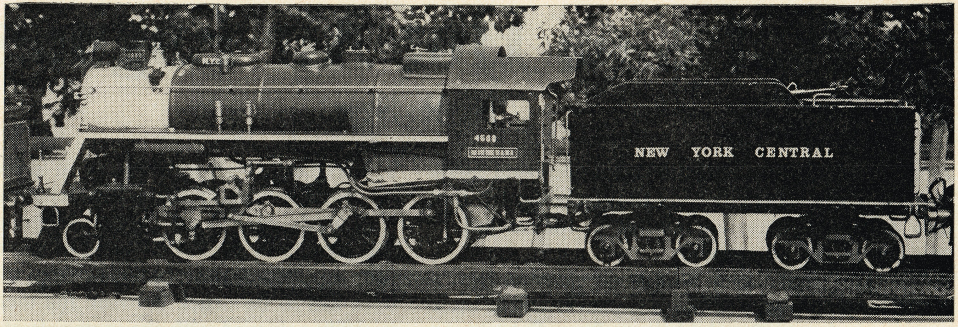
Ewart Haswell drives his 5 in. gauge Stirling "single".



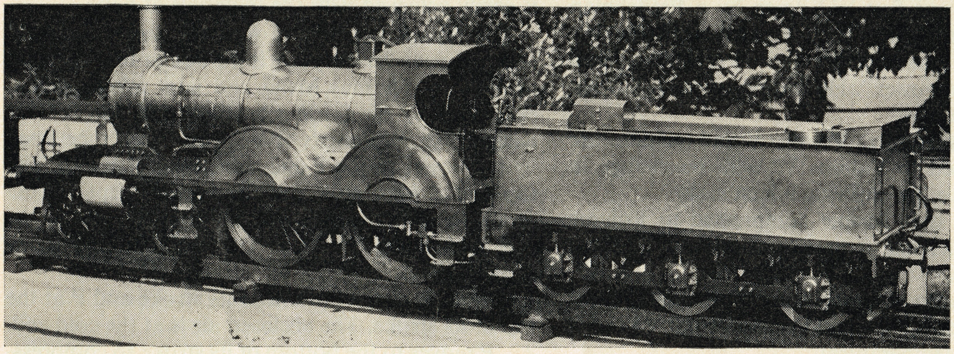
A 5 in. gauge "Minx" 0-6-0 by John Richardson of Keighley.

On left: A fine Hunslet 0-4-0 ST for 5 in. gauge by G. Tomlinson of Barnsley.

Below: E. Holden's 5 in. gauge "Papyrus" takes a good load.



Jack Davies' N.Y.C. 2-8-0 has been running for 13 years.

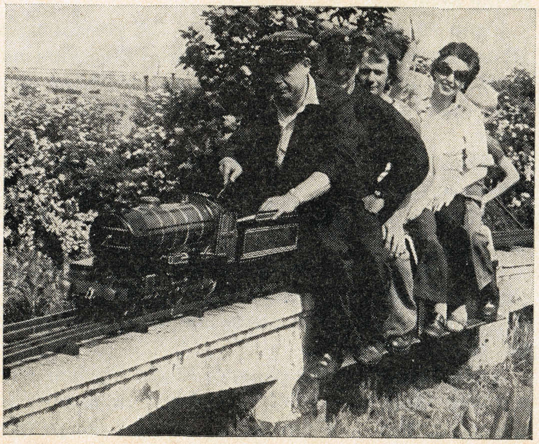


Now almost complete—Keith Massey's 5 in. gauge Adams L.S.W.R. 4-4-0.

engine to William Adams' celebrated design of the 90's. I did not see the Southwestern engine run, but the "Shire" certainly could pick up her heels with a good passenger load. She was built by W. Holland of Retford, and the "Adams" by Keith Massey of Stockport, who also has built *Firefly*.

Finally, in this brief selection from a total of probably forty to fifty engines (with another twenty or so in the marquee), let us just mention the veteran New York Central 2-8-0 *Minnehaha* brought by Jack Davies from Egham in Surrey. Despite being due for overhaul after thirteen years' running, the engine still puts up a good show. It will be recalled that Jack described his Virginia and Truckee R.R. locomotive in a recent issue, and as a point of interest he is working currently on his fourteenth engine.

W. Holland of Retford with his 5 in. gauge 4-4-0 "Yorkshire".

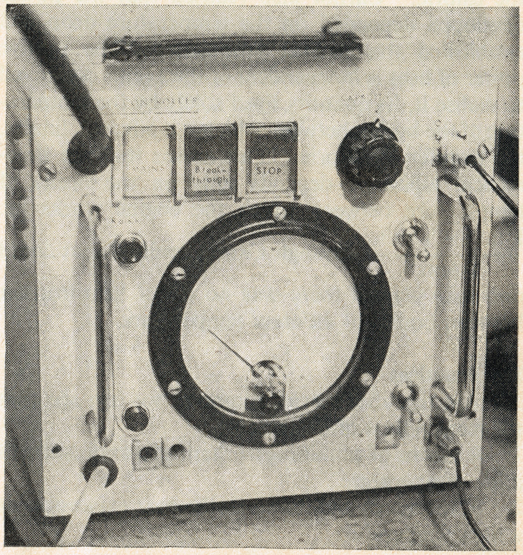


SMOKE RINGS

From page 841

There will be no less than twelve working small-gauge layouts, a live-steam passenger-carrying track, trade stands, demonstrations and a film show on the Saturday. M.A.P. Ltd will be having a stand for the sale of books and magazines. The opening times are 10 a.m. to 9 p.m. on 27th—30th, and 10 a.m. to 8 p.m. on the 30th.

The power unit of Mr. Griffiths' spark erosion machine.



Notes on Hot Air Engines

by R. Seir

THESE NOTES are not intended as a complete guide to making hot air engines but hopefully written that they might stimulate an interest in the subject, if only scaled down to models.

One thing that seems little understood is how a hot air engine works. The principle on which these engines work was first laid down by a Frenchman Sadi Carnot in 1824 in a book entitled "Reflection on the motive power of fire and on machines fitted to develop that power". He laid down the following cycle of operations:

1. A quantity of air at Volume V and temperature T is compressed to Volume V2 with no change in temperature (i.e. by applying a heat sink).
2. The air is then further compressed to Volume V3 during which the temperature rises to T2 (heat sink removed).
3. A heat source at temperature T2 is then applied to the air which is allowed to expand from V3 to V2 (no change in temperature).
4. The heat source is then removed and the air allowed to expand back to its original volume V with the temperature falling from T2 back to T.

Carnot found by experiment that the amount of energy produced by expansion of the air from V2 to V was greater than that required to compress the air from V to V2, giving an excess of power. "The air then", Carnot stated, "has served as a heat engine; we have, in fact, employed it in the most advantageous manner possible, for no useless re-establishment of equilibrium has been effected by the caloric." Carnot also realised that the power developed depended on the temperature drop and established the general proposition "The motive power of heat is independent of the agents employed to realise it, its quantity fixed solely by the temperature of the bodies between which it is effected, finally, the transfer of caloric." This means that the theorectical efficiency depends only on the limits of temperature between which the engine works i.e. $\frac{\text{T max} - \text{T min}}{\text{T max}}$ although Carnot realised that could only take place if there was no direct heat transfer between bodies of different temperature.

The Practices

From the above brief summary we can see that the main points of design are:

1. A means of obtaining isothermal compression at a low temperature.
2. A means of obtaining isothermal expansion at a high temperature.
3. Highest possible difference in temperatures.
4. No direct heat transfer between hot and cold ends.

A study of hot air engine design over the past 200 years will show that none of the above can be fully embodied in a practical design and a compromise has to be struck between the theory and what is easily achieved with the materials at hand.

The layout that has proved the most successful and popular over the years is the design first invented in 1794 by Thomas Mead and later taken up and developed by the Stirling brothers and others. This design (Fig. 1) consists of an open ended tube fitted with a power piston P and a displacer piston D. The top end is kept cold and the bottom kept hot. D serves to shift the enclosed air from the hot to the cold end of the chamber. The mode of operations is as follows:

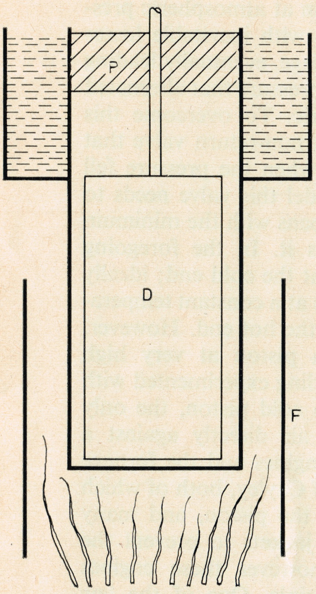
1. With D at the bottom of its stroke and P at the top of its stroke. The enclosed air is at the cold end.
2. P moves to the bottom of its stroke so compressing the enclosed air, any heat arising from compression of the air being removed by the cooler. (Isothermal compression at T min.)
3. D moves from the bottom of its stroke to the top so shifting the enclosed air from the cold to the hot end, the air will become heated and the pressure will rise. (Heat transfer at constant volume.)
4. P is then driven back to the top of its stroke. (Isothermal expansion at T max.)
5. D moves from the top to bottom of its stroke, the air is moved back from the hot end to the cold end and the cooler removes remaining heat from the air. (Heat transfer at constant volume.)
6. The cycle is repeated.

For simplicity the heater and cooler are omitted in the diagram.

From Mead's design of 1794 to the present time all hot air engine designers have faced the following problems and practically every patent taken out since then has been for improvements in one or the other.

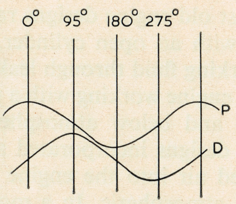
1. How to efficiently transfer heat from the heat source to the air.
2. How to efficiently abstract the waste heat at the cold end.
3. How to reduce the heat transfer along the heater chamber walls and through the displacer.
4. How to drive the displacer and shift the air from hot to cold ends.

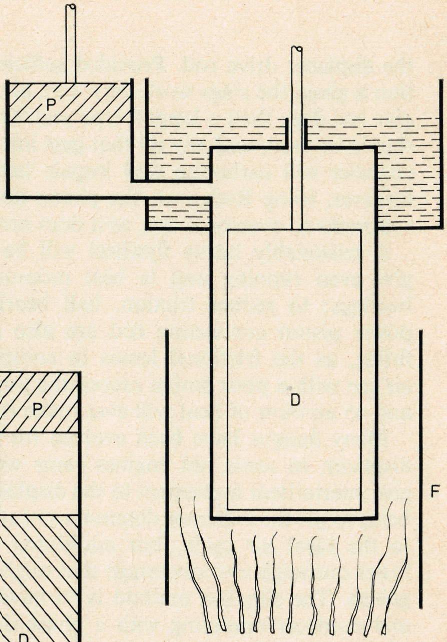
As can be seen in the pages of *Model Engineer*, the problem faced in making model hot air engines is not so much one of evolving an efficient design but



ENGINE BASED ON STIRLING 1816

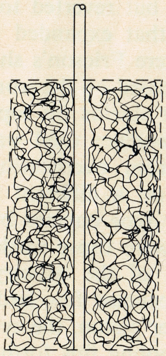
Fig. 3





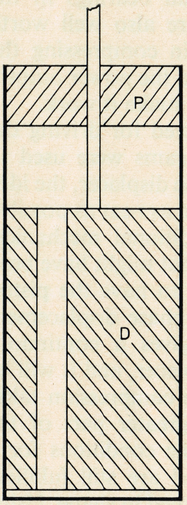
ENGINE BASED ON STIRLING 1815

Fig. 2



REGENERATIVE DISPLACER

Fig. 4



HEADS ENGINE 1794

Fig. 1

making one that actually works. The following designs have been evolved by experiment by the author and give a fairly compact engine layout, which though thermodynamically not very efficient is capable of giving a reasonable power output.

Fig. 2 shows a layout to Stirling's design of 1815 with the following design parameter:

i. length of displacer chamber L = 3 times its diameter.
ii. length of heater chamber = $\frac{2}{3}$ L
iii. length of cooler = $\frac{1}{3}$ L
iv. swept volume of displacer = $1\frac{1}{2}$ times swept volume of piston cylinder
v. length of displacer = $\frac{2}{3}$ L and stroke = $\frac{1}{3}$ L

The idea of having the hot chamber longer than the cooler is to get a temperature gradient from hot to cold end of the heater chamber. When using thin walled tubing for the heater there is bound to be some heat conduction along the tube and extending the length is one way of reducing it; this design feature can be found in many old engine designs, but in modern designs special metals are used to overcome this problem. The displacer chamber is best made in two parts joined with a low heat conducting washer. I use brass tubing since it is easier to work with, but stainless steel would enable higher temperatures to be used; this type of heater is not very efficient but is the simplest to make.

The ratio of swept volume of displacer and piston gives a reasonable compression ratio, ideally it should be nearer unity, but this gives rise to greater mechanical losses through friction which are difficult to overcome in a small engine. It seems that you can't scale nature, the smaller the engine the greater the frictional losses in proportion to the power developed.

The most effective means of cooling is with a water jacket as shown, natural air cooling fins tend to give over heating unless quite large, and forced air cooling can absorb nearly all the power of the engine. Small models can be heated by a meths burner, and larger models by gas flame, the use of a flame guide (F) helps to keep the flow of hot gases along the hot chamber wall, the gap between it and the heater will depend on the size of flame being used, too small a gap will reduce flow and choke the flame. The piston can be lapped in to give a good seal with a couple of oil grooves but I prefer to use rubber "o" rings of the type supplied by Model Engineering Services. The piston is fitted slightly looser than a lapped piston and a groove machined to take the "o" ring; "o" rings are also used to seal the displacer drive rod. Provided sufficient lubrication is given the rings work very well, and appear to give less drag than a lapped type seal. Only thin oil should be used, and any oil that gets into the heater chamber will carbonise and impair heat transfer; however, using Redex on the piston and displacer rod seems to overcome this, as it does not carbonise.

A reasonably heavy flywheel will be needed to give even running and is best mounted on ball bearings: to reduce friction, ball bearings in the power piston connecting rod are also well worth fitting, as the frictional losses in compressing the air can with a poor design exceed the power output, and no amount of heat will ever make it work.

Many designs have been evolved for driving the displacer, in some old engines cams were used to give intermittent movement to the displacer, the idea being to get the indicator diagram as near as possible to the ideal air cycle, but additional mechanical losses outweigh any advantage that might have been gained. The simplest method is to have the piston and displacer operating with a phase displacement of between 90° – 110°, this gives a continuous sinusoidal movement of the displacer, and it will be found that a greater part of the compression takes place in the cold end, and a greater part of the expansion in the hot end, so the conditions for a surplus of work to be produced are still fulfilled. The indicator diagram becomes oval in shape. Using an angle of 95° enables a simple linkage to be used.

In the cycle of events, the max pressure obtained will depend on the amount of air taking part in the process. This causes a factor called the dead space to be considered, this is the mass of air that takes no part in the process and assumes an average temperature, too large a dead space will reduce the overall efficiency by reducing P max. Fig. 3 shows a layout following Mead's design, as improved by Stirling in 1816, which is more compact. The overall length of the displacer cylinder needs to be increased so as to accommodate the power piston, but need not be extended to cover the complete stroke of the piston since as shown in the graph the strokes of the displacer and piston can be made to overlap, so reducing the amount of dead space. The displacer drive rod is passed through the centre of the piston. Since the power depends on the amount of air being moved by the displacer, the power can be varied by varying the length of stroke of the displacer. The power can also be increased by using denser air, i.e. compressed air, but there is little advantage unless a sealed crankcase is used, the crankcase being pressurised up to the minimum operative pressure in the engine. By arranging for the crankcase to communicate with the interior of the engine when the power piston is at the bottom of its stroke, the power can be simply varied by altering the crankcase pressure.

Most old engine designs ran at atmospheric pressure, with an open cylinder, with inevitable losses of working fluid through leakage, eventually leading to the engine working with a pressure that alternated above and below atmospheric. To overcome this many designs incorporated a non-return valve that allowed air into the engine when the pressure fell below atmospheric. In a model this valve needs to be lightly loaded so that it opens with the minimum of pressure difference across it. In the foregoing designs the piston is placed at the cold end; ideally to ensure that the air expands at a constant temperature the piston should be at the hot end. However, operating and lubricating a piston at very high temperatures is not easy. Stirling experimented with the idea but reverted to the cold piston, the only engines that expanded hot air directly against a piston were Ericson's ship engines and the furnace engines based on the work of Cayley, both of which had heat shields on top of the piston, and many furnace engines used water jackets to prevent the piston from overheating, however these engines worked on a different principle. One of the few displacer type engines built commercially with hot pistons were those made by Essex in America, at the turn of the century. The Essex model E, a kitchen exhaust fan, had the hot cylinder acting as the power piston, the cylinder sliding up and down inside cooling fins forming the cold end. I understand from Andrew Ross in Ohio who has one of these engines that it has a high compression ratio and runs at about 500 r.p.m.

The Economiser

As early as 1797 it was found that greater ecomony in running could be obtained in air engines by utilising some of the waste heat, but the development of the regenerative principle was largely due to the work of James Stirling. In many old air engine designs the regenerator was completely omitted, since simple construction was a greater selling point than economy in running. The engines themselves were usually so grossly inefficient, that there would have been little point in fitting a regenerator, but many of them worked steadily with little or no maintenance for upwards of 50 years which was all that was required. Those were years free of energy crises when an extra few buckets on the fire mattered little. It might be argued that because of possible extra friction there is little point in fitting one in a small engine, but they do seem to run better when one is fitted. The type that was fitted to the Robinson engine is the easiest to fit (Fig. 4). I fitted two perforated discs to the displacer rod with a diameter less than the internal diameter of the cylinder, and the distance between them corresponding to the required length of the displacer. Fine wire wool is then wrapped round between the discs, the wire

Continued on page 850

A VERTICAL COLUMNAR ENGINE

"Tubal Cain" describes how to build a model of the "Williamson" engine

Part III

From page 820

WHEN DRILLING the main bearings, feed steadily to avoid the drill wandering—don't apply great pressure; just let the drill cut naturally. Now enlarge, to your $\frac{1}{4}$ in. reaming size (I use letter D) a step at a time so that each drill has only a few thou. to take out. Finally fit a $\frac{1}{4}$ in. reamer and, using the rack handwheel, put the reamer through at about 300 r.p.m. Remove the vertical-slide (and the job, don't forget!) and make a little stub mandrel to fit the brasses. Machine the top flanges equally each side of the boltholes and face the ends to dimension. Form a little countersink each end of the hole. Finally, shape the ends of the flanges as shown on the drawing and refit to the entablature so that they don't get lost.

Preparation for the sideplates comes later, as do the governor fixing holes, but you must now store this part so that (a) it doesn't rust and (b) doesn't get oily. A tin box with a bit of VPI paper in it is best.

Flywheel, Part H

So far as can be seen from the catalogue the flywheel was not machined, a separate belt pulley being used, so there is no machining allowance on the casting. But it may need a bit of trimming here and there, and the casting should be so true that if you *must* skim the rim you can safely take off a bit if you want to. Before machining, do all the preparatory work for painting on the spokes etc., and then clamp (Fig. 6) to the faceplate setting the rim dead true. Don't clamp too hard. Face the boss and then drill and ream (or, better, bore) $\frac{1}{4}$ in. There is no need to face the other side of the boss, but if you do I suggest doing it on a stub mandrel. Finally, drill and tap for the setscrews, and re-prime all the parts you have filed up.

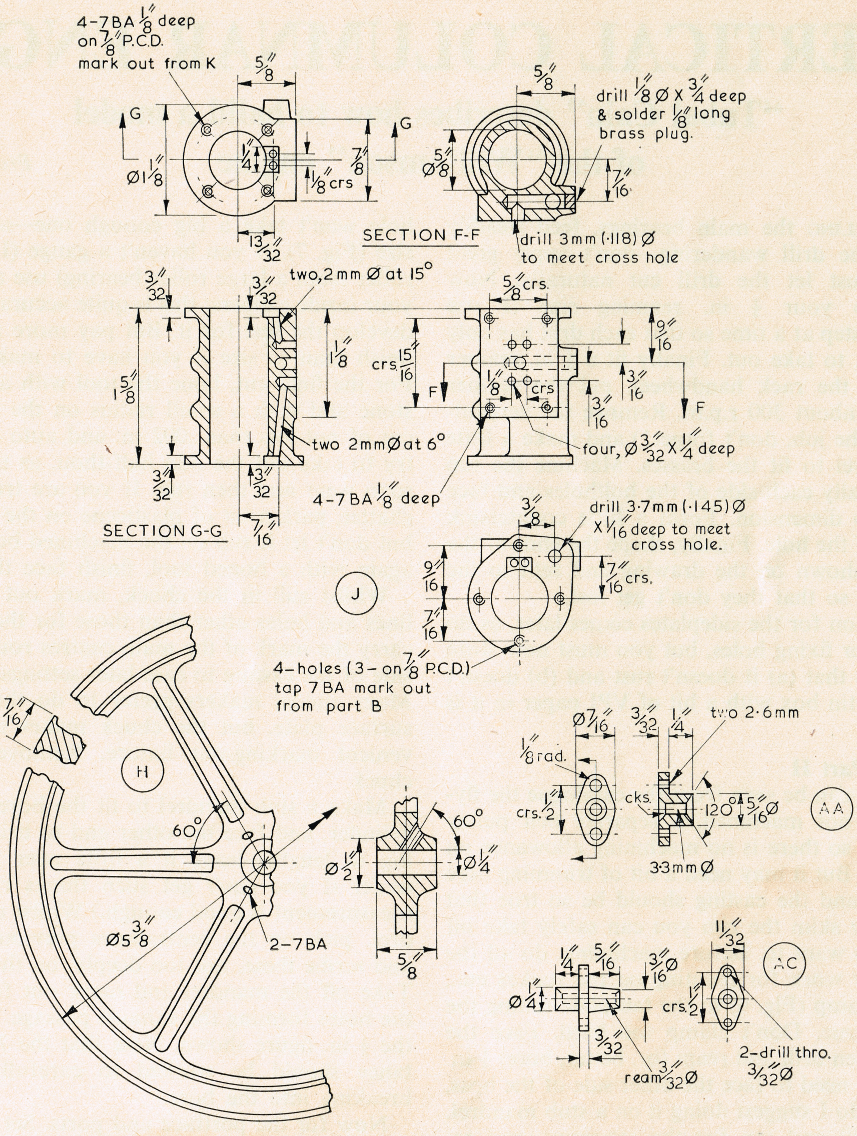
Cylinder, Part J

This is a gunmetal casting. Check it with your square and file the top (circular flange) till it lies square to the general body of the casting. Lay your rule on it and decide how much must come off this flange to equalise the thickness of both when finished. (It should be 3/32 in. thick when finished, when the face is $\frac{1}{2}$ in. from the bottom of the portface.) Set up in the 4-jaw, base outwards, true to the outside of the casting—it doesn't matter if the bore runs out a little. Face the end, using the dimension previously decided, but leave on a few thou. Use as stiff a boring bar as you can—you may have to change to a larger one if the cored hole won't take a big enough one—and bore to size (Fig. 7). If you haven't a gauge (I use a $\frac{5}{8}$ in. roller from a large roller bearing) use a mike over your inside calipers; this is quite accurate once you develop the feel for it. But pay more attention to finish than to size if you have to make a choice. For the final cut, hone the tool with an Arkansas stone and with a small radius on the nose; use a cut of not less than .002 in. and auto feed—don't try to take out the odd half-thou. as the tool will soon wear and then rub. If you are troubled with chatter, park a bit of plasticene on the boring bar, but don't let it rub on the machined bore. Finally, again with a honed tool, finish face the end.

Whilst still in the chuck, mark out for centre-lines and holes other than those for the studs, and carry the mark of the main centres round the outside of the casting to ease later settings. See Fig. 8. Many model makers prefer to do this job on a surface plate, but the chuck makes a very convenient marking-out fixture. Remove from the chuck.

Make a stub mandrel to fit the bore, set up the cylinder, and face the other end to bring the casting to length—leave it a little over rather than under if you *can't* get such things right! (Rule measurement is good enough.) Whilst on the mandrel, pick up the centre-lines previously marked and scribe these, not too deeply, on this face also. Take off the mandrel and mark out for and drill the holes forming the exhaust passage. Spotface at the $\frac{5}{8}$ in. figure shown. Note that the 7/16 in. distance should be worked to carefully to avoid breaking into the bore.

Now for the portface and ports. Set up the vertical-slide and check it for squareness. Mount the cylinder, top outwards, as in Fig. 9, and fit the sharpest milling cutter you have (or get busy on your Quorn!) in the 3-jaw. Set the cylinder square to the marks, and take care that you have a good-sized washer under the nut. Engage the leadscrew handwheel to apply cut, and machine the whole portface. You are going to have to "flat it off" to get a good face for the valve later, I know, but nevertheless, aim for a good finish. With the same set-up you can drill for the ports, using the co-ordinate method I described some time ago and thus avoiding all marking out. For convenience I show the dimensions redrawn from the top face of the cylinder in Fig. 10 as reference plane. The procedure is now well-known, so I won't go


4-7BA 1/8" deep on 7/8" P.C.D. mark out from K
5/8"
G
G
Ø1 1/8"
1/4"
7/8"
1/8" crs
13/32"
SECTION F-F
5/8"
drill 1/8" Ø x 3/4" deep & solder 1/8" long brass plug.
5/8" Ø
7/16"
drill 3mm (·118) Ø to meet cross hole
3/32"
3/32"
two, 2mm Ø at 15°
5/8" crs.
9/16"
1 5/8"
1 1/8"
crs. 15/16"
F
F
1/8" crs
3/16"
3/16"
two 2mm Ø at 6°
four, Ø 3/32" x 1/4" deep
3/32"
3/32"
4-7BA 1/8" deep
SECTION G-G
7/16"
3/8"
drill 3·7mm (·145) Ø x 1/16" deep to meet cross hole.
9/16"
7/16" crs.
J
7/16"
4-holes (3 - on 7/8" P.C.D.) tap 7BA mark out from part B
7/16"
H
60°
Ø5 3/8"
2-7BA
60°
Ø 1/2"
Ø 1/4"
5/8"
Ø 7/16"
3/32"
1/4"
two 2·6mm
1/8" rad.
crs. 1/2"
cks.
120°
5/16" Ø
AA
3·3mm Ø
11/32"
AC
1/4"
5/16"
3/16" Ø
Ø 1/4"
crs. 1/2"
3/32"
ream 3/32" Ø
2-drill thro. 3/32" Ø

through it all again, but will remind you to come up to the final setting on each handwheel in the same direction each time. I always mark an arrow with a felt pen as a reminder! I recommend that you centre all holes with the Slocumbe first, and then return to settings to drill—it saves time and reduces the chance of error. Don't centre too deeply, or you will have a port with bevelled edge. If this does happen, just machine a few thou. off the port-face.

Remove from the machine, and set up to drill the steam passages. Fig. 11 shows two ways of doing this—and I can assure you that the poor man's way in 11b is just as effective as the other.

Mark out the positions, $\frac{3}{8}$ in. from the cylinder centre and $\frac{1}{8}$ in. apart, and then drill No. 45 vertically for about 1/16 in. deep. Then set up either on the wooden wedge, in an angle vice, or an adjustable angle plate as shown. I have quite a number of wooden wedges like this, different angles, to which jobs can be attached quite simply with woodscrews, and very handy they are. The drill will start in the small pilot hole with no difficulty, but they are deep holes for this size and you must clear chips frequently. Take care when breaking through. This having been done you can cut out the recesses in the flanges—mill, chisel, or even just file a bevel. The steam speed is so low (the engine turns on a whiff) that so long as there *is* a passage you won't notice the difference.

Remove all burrs and set the cylinder up on the base, part B. Take care that the cylinder is aligned

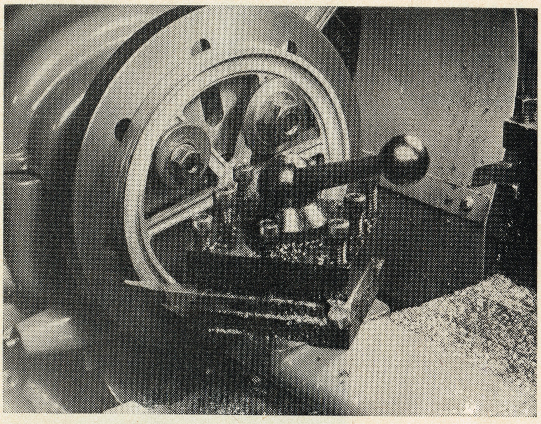


Fig. 6: Flywheel clamped to faceplate to machine boss.

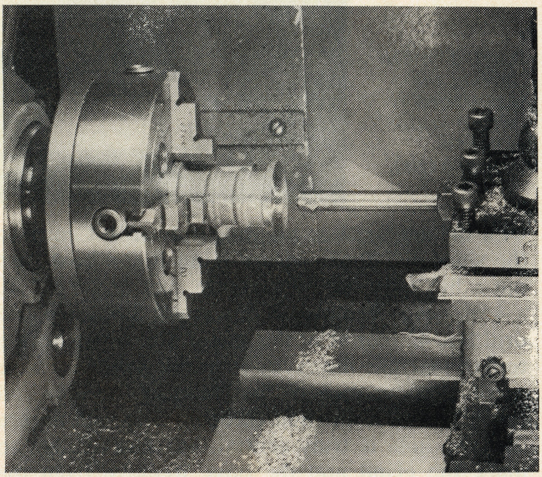


Fig. 7: Boring the cylinder.

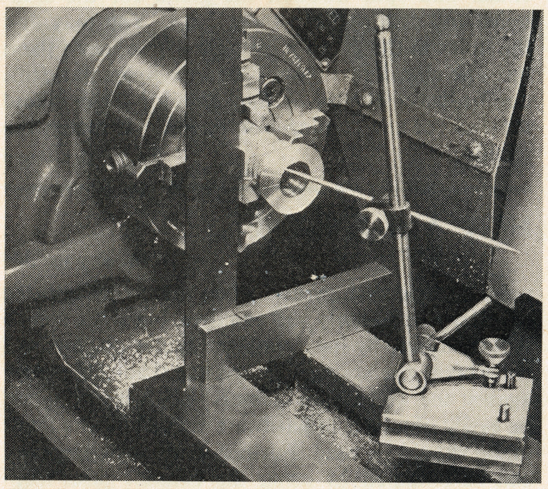


Fig. 8: Marking out the cylinder flange.

to the centre-lines and facing the right way round (portface facing the flywheel side). Clamp up, and recheck alignment. Spot through one hole, drill and tap this, fit a screw, and check alignment again. Draw the hole till it's right (if it's wrong, that is!), fit the screw *and* the clamp, and spot through for the other holes. Drill and tap for these. Note that the drill and the tap will break through half-and-half in the outside of the cylinder wall, and in soft gunmetal there is a chance of this pulling the hole sideways. Best to set the depth stop on the drill if it has one. Leave all other holes in the cylinder till you have made the mating parts.

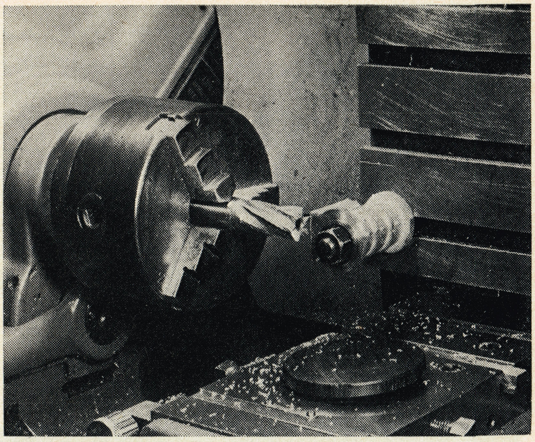
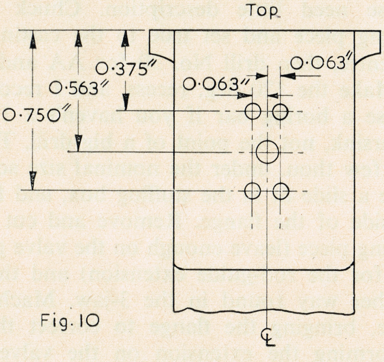
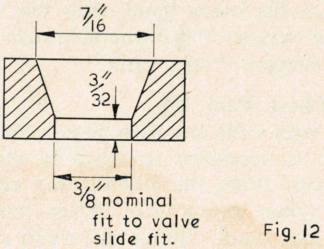


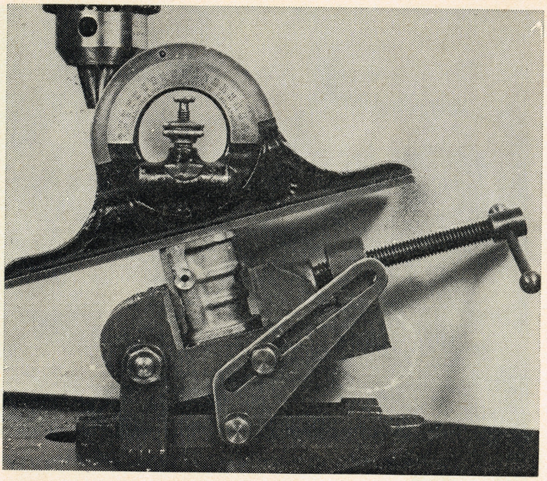
Fig. 9: Machining the port face. Note cover over top-slide seating.



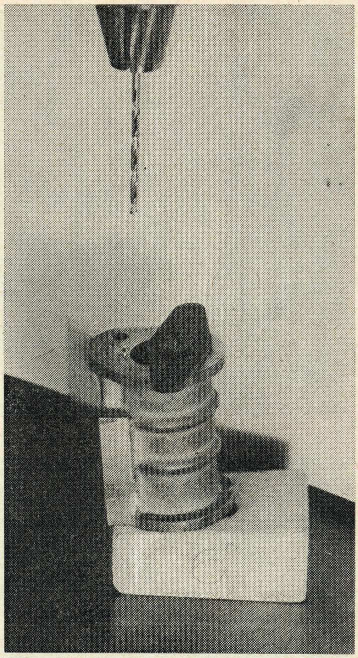
CYLINDER PORT LAYOUT



CROSS SECTION OF STEAM CHEST



Left. Fig. 11a: Drilling the steam ports using an angle vice.



Right. Fig. 11b: Drilling the steam ports using a wedge of wood (6 deg. angle).

Glands, Parts AA and AC

These need little description. Chuck by the chucking piece and set true to the casting. Face and centre, then drill No. 30 for AA and 41 for AC. Make the 120 deg. recess, and I recommend you use a boring bar if you haven't a 120 deg. countersink, not the point of a big drill. Turn the OD a few thou. under the nominal size so that it will be a slide fit in the stuffing box, and face the underside of the flange. Remove and cut off the chucking piece (leave enough on the valve gland to allow for the rod-guide extension) and then grip the other way round in the 3-jaw. Machine the outside, bringing the flange to correct thickness and forming the extension on the valve gland. Countersink the rod-hole. Mark out for the bolt holes and, after removing from the machine, scribe circles for the ends of the oval *before* drilling the holes. On the other hand, drill the holes before filing the oval, so that if one hole runs out you can file the shape to "look right"!

Steam Chest, Part AB

Trim with a file and then grip in the 4-jaw using packing as necessary to machine the front and back faces; bring the stuffing box central to the casting when doing this. After machining the second face mark out for the width of the cavity and the four bolt holes and for the overall width and length of the casting. Remove from the chuck and drill the bolt holes, then file or mill the outside. The purpose of the odd shape in the cavity is to guide the valve, so carve it out. The rubbing faces should be parallel to each other and to the longitudinal centre-line and about 3 thou. clear on the valve. (It is worth trimming the sides of the valve and fitting it to the chest at this stage.) The rest can be chewed out with a coarse file—or your teeth, if you like.

Rechuck in the 4-jaw using lead or other very soft packing to avoid marking the machined faces, with the stuffing box pointing outwards. Centre to the sides and faces—never mind if the boss runs out a bit. Face the boss, centre, and drill 7/32 in. x $\frac{1}{4}$ in. deep. Recentre with a small Slocumbe and drill No. 42 (*not* 41 at this stage). Use a tiny boring tool to machine the cavity to fit the gland you have made already; then fit the gland in the hole and run a No. 41 drill right through. This will ensure that the hole is truly central, but don't forget to mark the gland and the boss. Remove from the chuck and spot through the gland for the stud-holes and drill and tap these 7 BA. You may find the holes in the gland a bit tight—if so, open them out one size. I like close clearance holes but drills don't always behave as they should! Trim round the oval of the stuffing box to make it match the gland.

To be continued

HOT AIR ENGINES

From page 846

wool is quite springy and when first fitted into the cylinder will be fairly stiff to move, but if the engine is turned over by hand with the heater on, the heat soon takes the spring out and the wool fits snugly against the wall of the cylinder. The wire wool can be easily obtained in hardware shops and the finest grade should be used. Further increase in efficiency can be obtained by using the exhaust gases from the heater to preheat the incoming air to the burner, but this is not too easy to do with small meths burners and it is not really worth bothering with unless a more efficient type of heater chamber is used.

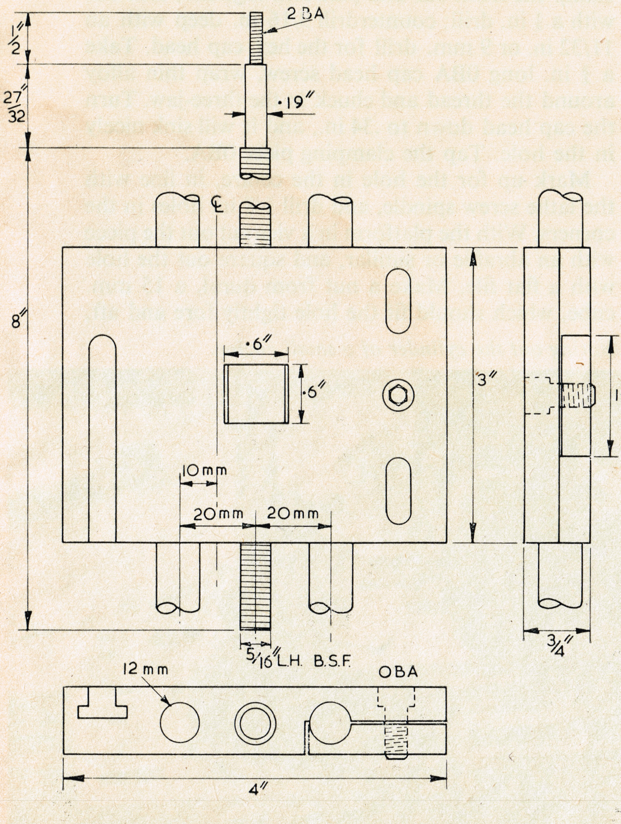
ACCESSORIES for the "UNIMAT"

A Boring Table *by R. L. Tingey*

THIS BORING Table was made after trying to bore a block of dural for the cylinder block of a model aircraft engine and finding that the cross-slide position permitted a central hole to be bored only in material less than one inch square. The cross-slide is only 12 mm. below centre height, and this means the size of a bore is very limited if some material is to be left around the hole.

This platform for the Unimat gives the new capability of enabling holes to be bored centrally in block material up to 2½ in. square using a boring bar and bit turning between centres. With a 6½ in. bar a hole can be bored through 3 in. of block with precision. The platform itself is made on the Unimat with a bit of a struggle.

Basically the platform is a low-slung block of ¾ in. thick dural with its own threaded spindle which is provided with a nut to drive the platform; this simplifies the problem of threading the platform itself. The precision of the job is supplied by two devices, the drilling and reaming of the main guide hole, and the final milling of the top surface parallel to the slide bars and across.



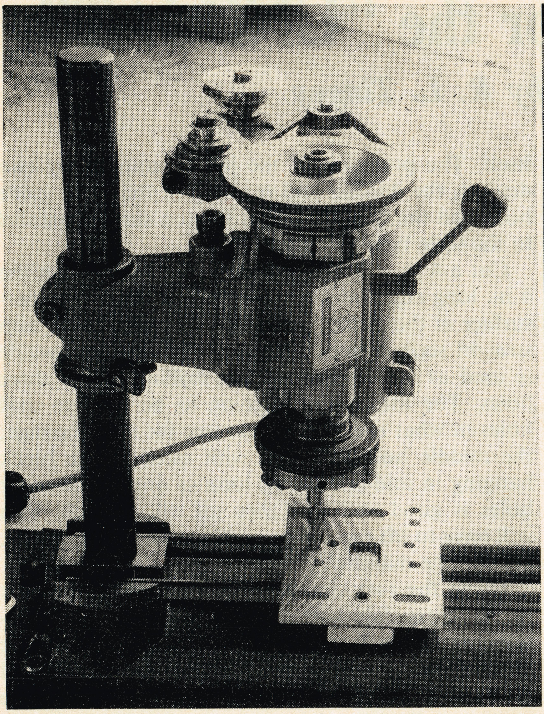
A BORING PLATFORM FOR THE UNIMAT

Cut a 4 in. x 3 in. piece of dural. Mark both the 4 in. long edges and across what will be the undersurface at the centre, and at 20 mm. either side with straight scribed lines. The surface of the cross-slide is used as a reference for the drilling of the three holes. The little lathe is going to be used to drill holes in what is a large workpiece for it to manage; the middle hole is drilled with most of the block hanging in mid-air, but as long as one of the outer holes is good and true then all will be well. You will have to lift the motor and bracket about 45 deg. around the mandrel.

Using the two clamping claws, clamp the block to the cross-slide with the bulk of the work overhanging the back of the lathe, scribed side up. Line up the scribed lines parallel with the lathe bars and clamp down tightly. Move the cross-slide until the nearest scribed line is at centre and lock the cross-slide. Drill through using a long ¼ in. drill, then drill through again with a 7/16 in. drill using a slower speed and some paraffin squirted down the ¼ in. hole. If there is a chance of the block shifting position when drilling with the large drill use a 5/16 in. and a 3/8 in. drill as intermediates before the 7/16 in. Loosen the cross-slide and bring the middle scribed line to centre, tighten the slide and drill through with ¼ in. drill. This time the series of 1/16 in. steps will certainly be needed as there is great leverage at the holding clamps. It is at this stage you will realise how flexible the little lathe is. This is an oversize hole to accommodate the threaded rod and great accuracy is not essential.

Loosen the clamps and turn the workpiece around, same side up, and carefully line up with the lathe, centre and clamp up tightly. If your first hole was not very successful now is the time to revise your methods. More lubrication, different drilling speed or pressure, perhaps you should use the mandrel to drill instead of the saddle movement; this is another chance to get the best straight in-line hole in a rather inadequate situation.

With the alloy block held in a vice, ream the two outer holes using a 12 mm. straight reamer, with a little tapping compound on the taper. Decide which is the cleanest, straightest hole and cut away half the other hole, sawing through the scribed surface and the block's end. Start the sawcut on the scribed surface to just miss the inside of the hole so that you

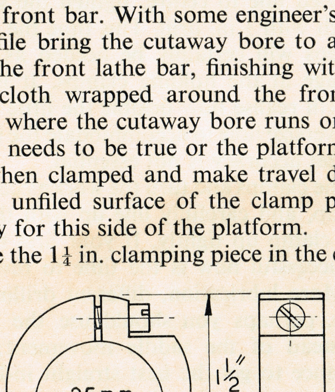


Swing milling the platform using the column collar.

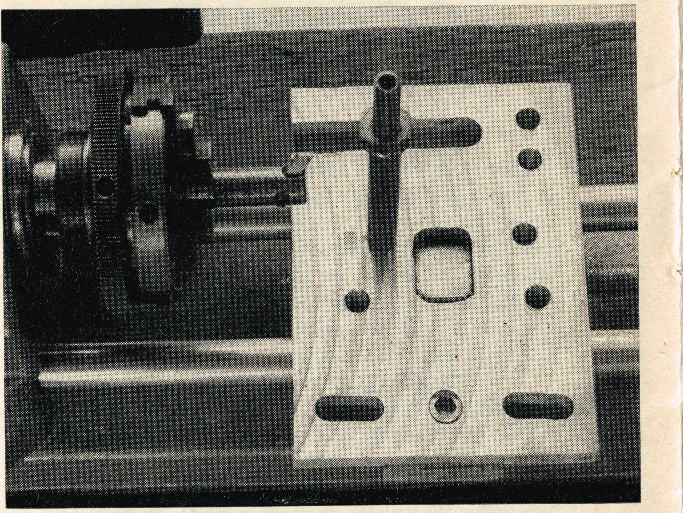
end up with most of the surface of the bore left intact. Take the piece removed and cut off 1¼ in. of it for the clamp.

Dismantle the lathe and slide one lathe bar into the 12 mm. bore, lubricating with machine oil. Bolt the two bars back onto the bed, the bar with the platform on at the back, and check how the cutaway fits the front bar. With some engineer's blue and a round file bring the cutaway bore to a reasonable fit on the front lathe bar, finishing with some fine emery cloth wrapped around the front bar. The surface where the cutaway bore runs on the top of the bar needs to be true or the platform will try to twist when clamped and make travel difficult. The reamed unfiled surface of the clamp produces the stability for this side of the platform.

Place the 1¼ in. clamping piece in the centre under the front bar and secure it in place with a couple of small clamps. With the headstock on the column, drill vertically right through at the clamping bolt position, with a No. 11 drill. Remove the piece and clamp the front bar and platform together, drill out with a ¼ in. drill; counterdrill 3/16 in. deep with an 11/32 in. or 9 mm. drill for the hex. cap head. Take a ¾ in. long 0BA cap head screw, wrap thin alloy around the thread and chuck in the three-jaw. Turn the cap head down to .34 in., and it will sink nicely in the hole. Tap the clamping piece 0BA.



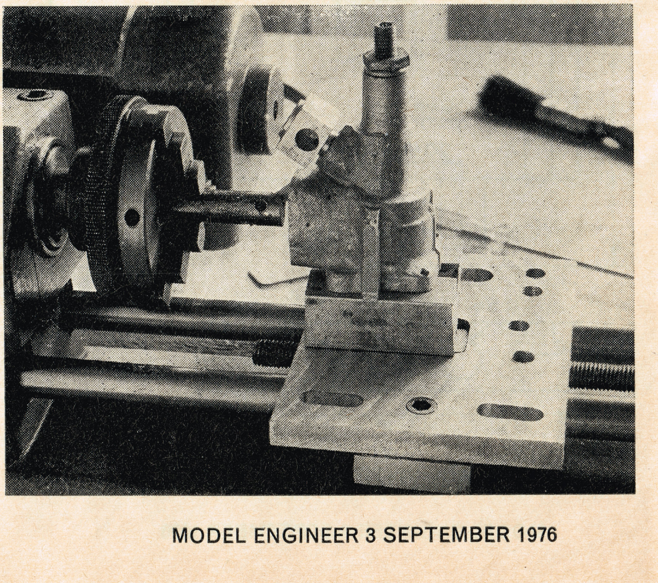
COLLAR FOR UNIMAT COLUMN



A sturdy boring tool for boring blind holes up to 1 in. dia., using the platform.

Mark up for the hole in the centre, in line with the lathe screw spindle, and drill 1/8 in. holes in the corners. With the platform in a vice cut out the piece with an abrafile or similar, and square out the hole with a flat file. Make a nut from dural, a 15 mm. cube, which should fit the hole tightly fore and aft,

Boring out the cylinder of a small engine.



but should have a little sideways play, to help centring on the threaded rod. Drill the nut through with a ¼ in. drill and tap through with a left hand 5/16 in. BSF tap.

Take 10½ in. of 5/16 in. dia. b.m.s. and chuck in the three-jaw. Now since the lathe will only take 6¾ in. between centres the tailstock cannot be used, as such, and the rod can be supported by a three point steady. A better solution, however, is to dismantle the works of the tailstock, pass the rod through the hole, use plenty of grease and a bush to support and centre the work. The bush needs to be 5/16 in. inside diameter and .475 in. outside. Turn it from ½ in. brass or alloy rod, half an inch is plenty, and secure it in the back of the tailstock hole with the locking screw, pump in some grease and feed the rod through, securing 1 in. of the other end in the three-jaw chuck.

1/16 in. away from the jaws turn down 1½ in. of the rod to .19 in., then turn 21/32 in. of this nearest to the chuck, down to .185 in. Remove the rod and file two flats on the inch which was hidden in the chuck. Put the flats in a vice and thread the rod right down with a left hand 5/16 in. BSF die, opened right up: use plenty of tapping compound and backing off. Repeat the operation two or three times, closing the die a little in the stock each time, until the nut screws on tight to the fingers. Cut the threaded rod off at the vice leaving half an inch of the .185 diameter to be threaded 2BA.

The components for the platform are now all made and can be assembled on the lathe bed, using the handwheel and nut off the dismantled saddle assembly. Lubricate the bars, thread and handwheel with light oil, and with the clamp half tight run the platform back and forth; it should be as easy to run as the nut on the threaded rod will allow.

The next job is to mill the platform flat to the lathe, but the platform has movement only between head and tail, there is no cross movement. To overcome this problem make a "swing" milling attachment using the vertical column and headstock adaptor swinging around a collar clamped around the column. I made a swing collar from an old brass lathe dog, but one can be easily made from 1½ in. dia. brass. Turn half an inch of this eccentric in the four-jaw chuck, boring out a hole 25 mm. dia. and then facing off. Cut a flat to take the clamping screw, drill the flat through No. 33, then saw through the widest part of the eccentric, drill out the flatted side No. 26, and tap the other side 4BA to take a ½ in. long screw. File any rough spots off the headstock adaptor casting where it will bear on the collar. Clamp the collar onto the lower part of the column (where it is little used) and bring down the adaptor. With a small amount of fine grinding paste mate the two surfaces, dismantle and clean thoroughly with paraffin. When using the swinging action oil the column above the adaptor and at the collar, clamp the adaptor in use so that some pressure is needed to swing it.

To swing mill the boring platform, set the mandrel ¼ in. forward in the headstock and set it up truly vertical on the column. With a 5/16 in. endmill in the three-jaw chuck bring the adaptor down the column until the endmill is resting on the platform. Clamp the adaptor, bring the collar up to the adaptor and tighten the screw, unclamp the adaptor to swing, and oil. The 5/16 in. endmill is the optimum size for this job in this small lathe; use about 850 rpm.

Starting with the mill behind the platform and holding the headstock firmly swing the mill towards you and then back again over the same path. Move the platform ¼ in. and repeat until all the surface has been covered. This first go will only take off any high spots, but it gives a very good idea of the direction in which the rotating mill has a mind of its own. Now, with the cutter over the back of the platform loosen the mandrel screws slightly and lower the rotating cutter about 1/64 in. into the platform with the lever. Retighten the screws and mill all over the platform as before. Repeat until the platform is patterned evenly all over.

The only job left to do is to drill the holes wherever you want them, and to cut the slots. The holes I made are all tapped 0BA and two of them are directly under the lathe centre line; useful for boring out the cylinder blocks of model aircraft engines at 90 deg. to the crankshaft line. The T-slot takes Unimat claw clamps and is made with a 5/16 in. endmill 5/16 in. deep, followed by a ½ in. x ⅛ in. Woodruff cutter, bottomed on the groove.

Object of the platform

The main object of the platform is to make accurate holes for cylinder bores and so on; for this job you will need boring bars. These are readily made from mild steel rod and high speed steel tool bits ⅛ in. dia. Simply drill a hole in the centre of the bar with a ⅛ in. drill, at 90 deg. drill a No. 44 hole and tap 6BA to take a grub screw to hold the bit in place. The bit should be ground to a D section at one end, with a slight angle. I made one .275 in. dia. for boring up to ½ in. and a second .45 in. dia. for ½ in. to 1 in. bores. Centre drill the bars at both ends and they can be driven by a lathe dog.

This boring platform has made the Unimat more versatile and together with other modifications and improvements, enabled me to machine a 1 in. gauge steam locomotive, now almost complete, which is considered by some too large a scale for the small lathe. I hope to describe next a rounding off jig for cylinders and coupling rod ends, and also a three-point steady with greater capabilities than the standard accessory.

WITNEY AND WEST OXFORD SPRING RALLY

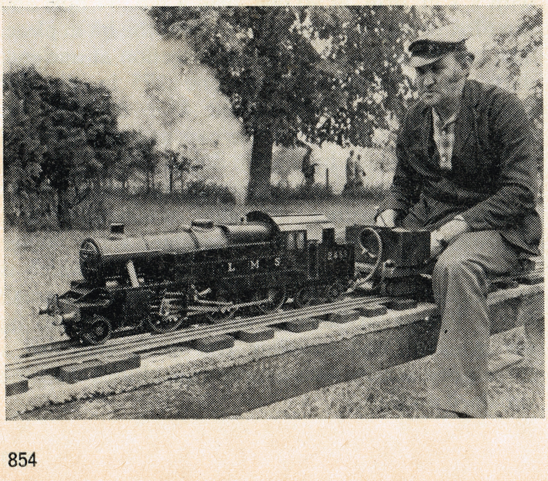
D. E. Lawrence

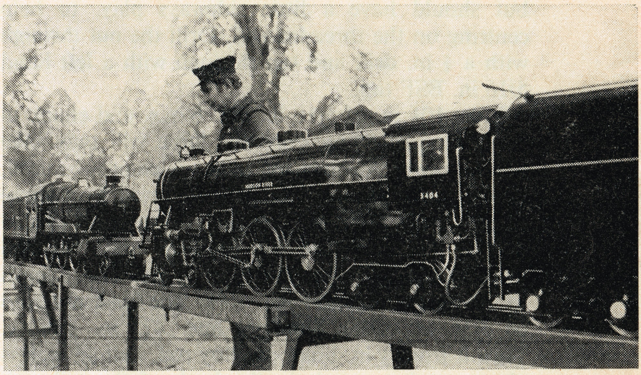
THIS SOCIETY usually has a good turn out for its popular Spring Holiday Rally and this year's attendance was probably the best yet, 35 visiting locomotives and 3 on show from the hosts. Conditions on the track were at times a bit crowded and a couple of engines were not unloaded. A year or two back, I mentioned that the L.N.E.R. B1 *Springbok* design by Martin Evans was becoming increasingly popular and at Blenheim there were no less than 5; another closely based on that design belonged to Neville Sanderson and he told me it was entered in I.M.L.E.C., and readers will now have heard more about this good looking locomotive in a previous issue. A real stranger to the British scene was Mr. R. Dimmock's powerful 3½ in. gauge New York Central type 4-6-4. The engine had been built by Arthur Stott and I was told that only photographs of the full size job had been used as a guide. The locomotive certainly had a genuine Transatlantic air.

Some years ago, Mr. H. Turpin's 5 in. gauge *Hackfly* was described in these pages and I remember some debate going on about certain aspects of the design. Well, Worcester member Billy Walker had one running and it gave no sign of having any design defects; it was pretty steady on the track with very little of the bobbing and tail-wagging usually found in 0-4-0T engines. Jack Owen of Coventry kindly offered me a spell at the regulator of his 11-year-old 3½ in. gauge rebuilt Bulleid *West Country* Pacific. There is a good deal of *Britannia* in this Pacific and one expected it to have a free steaming boiler and indeed it has, in spite of having to steam three over-scale cylinders. The boiler has overhung butterfly doors to the firebox and it was very easy to fire.

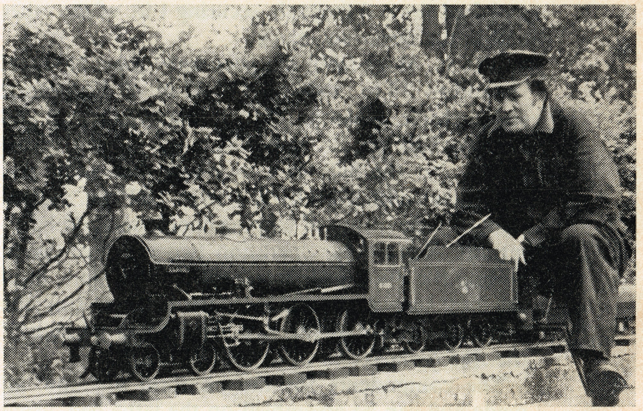
I built one of the first *Speedy's* in the country (I no longer have it) and I was pleased to renew acquaintance with a *Speedy* footplate when Bert Whitcher offered me a drive of his engine. It is equipped with a number of features alien to the Great Western, such as boiler feed steam pump, working turbo-generator and headlight. Bert threatens to make a pair of Standard No. 1 injectors

Bristol member Gordon Storey with his 3½ in. gauge "Jubilee".

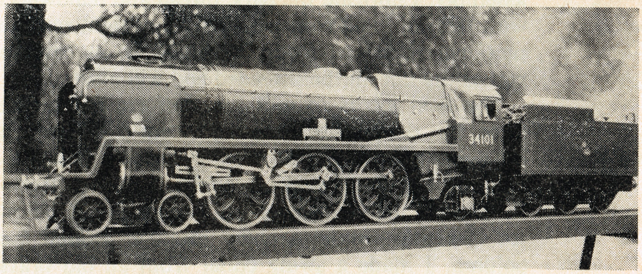




R. Dimmock's massive 3½ in. gauge N.Y.C. "Hudson River".

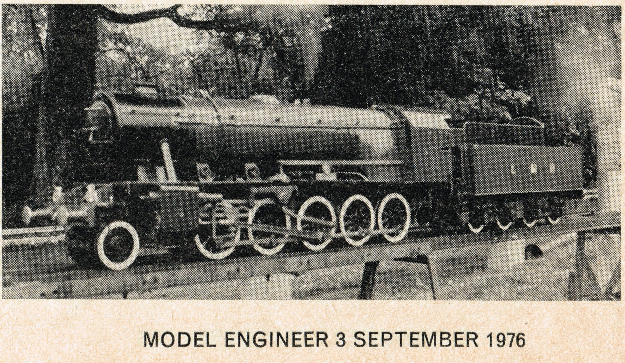


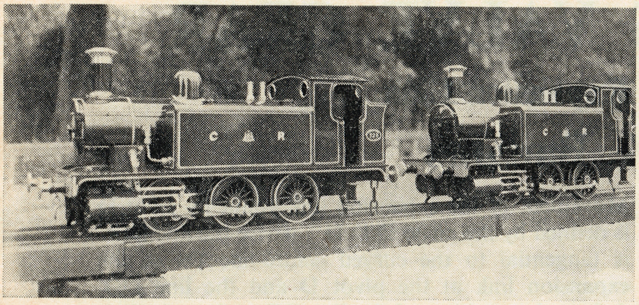
One of several 5 in. gauge "Springboks"—Brian Chapman of Portsmouth.



Jack Owen's fine 3½ in. gauge rebuilt Bulleid "Pacific".

Below: A steel-boilered 5 in. gauge 2-10-0 by Jim Rough of Bracknell.

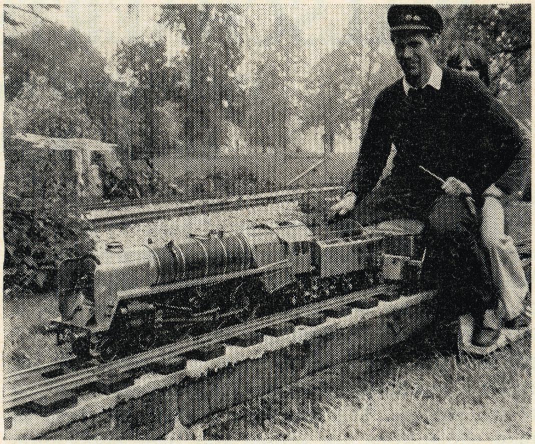




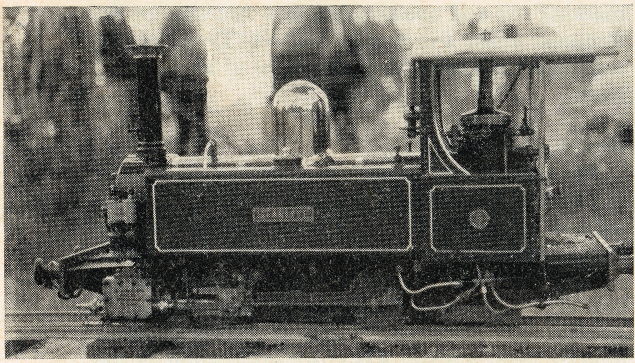
Identical twins—two "Rob Roys" by Bob Larkin and Dave Drover.

but I think he will continue to use his piston valve steam pump because he likes to see and hear things working. In this short report I cannot cover everything of course. but I should like to mention twin *Rob Roys*. These 3½ in, gauge identical twins were very nicely made and finished and they were the result of very close co-operation between Bob Larkin and Dave Drover, both of whom are from the Hatfield S.M.E. In these inflationary times, the economics of a co-operative venture by 2 or 3 people makes sense.

The Witney and W. Oxford members put in a lot of hard work into making this Rally a success, and they can be very pleased that their efforts were so well received; even the rain held off for them!

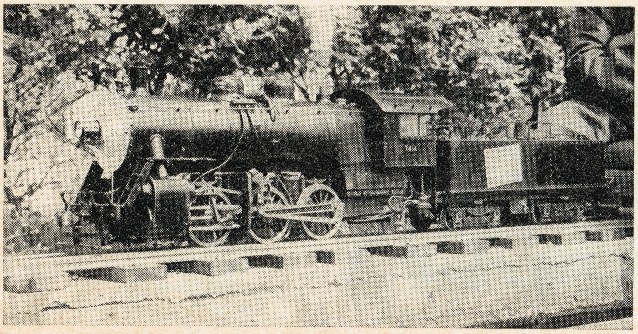


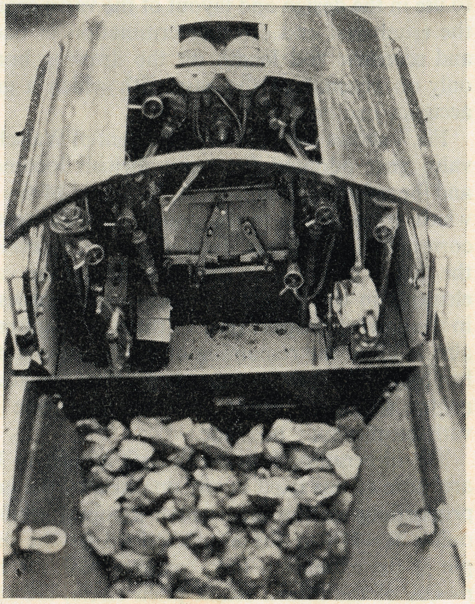
An unfinished "Britannia" by Martin Saunders of Bracknell.



An interesting 0-4-0 based on the "Hackfly" design by Billy Walker.

Below: Jack Talbot's 3½ in. gauge 0-6-0 based on a 2½ in. gauge design by LBSC.





The neat footplate of Neville Sanderson's modified "Springbok".

NEW "M.E." DRAWINGS

LO.947. "Super-Claud". 5 in. gauge G.E.R. 4-4-0 locomotive.

Sheet 1. General arrangement, frames, horns, stretchers.

Sheet 2. Driving and coupled wheels, axleboxes, crank axle, coupling and connecting rods, buffer beams.

Sheet 3. Cylinders, crossheads, arrangement of valve gear.

Price 85p each

WALSCHAERTS VALVE GEAR

The Design of the Expansion Link

by Dr. F. M. Burrows

Introduction

Calculation of the amount of back-set which is required at the driving pin of the expansion link in Walschaerts valve gear so as to give equal angles of swing about the central position of the link is not difficult and the mathematical treatment of this problem also leads directly to a formula for the eccentric rod length necessary for the proper working of the motion. The formulae derived for both of these dimensions are simple and their application in practical cases involves only very short manual calculation times. They are without doubt preferable to use in the design and layout of the valve gear than the usual trial and error determination of back-set and eccentric rod length on the drawing board if only on account of the ease with which a greater accuracy can be achieved.

Fig. 1 shows the usual arrangement of Walschaerts valve gear adopted for many British locomotives and the reference points O, A, B, D and M are those which are essential to the present calculations. The corresponding linkage diagram used in developing the theory is shown in Fig. 2, although the various elements in this diagram are shown not necessarily in the correct proportions. In these two figures, and also in all of the remaining ones, the same notation has been used for corresponding points, lengths and angles, so that a direct comparison of one figure with another may be made.

The dimensions L and H which appear in Fig. 2 are more or less fixed in any one case by the general proportions of the locomotive involved whilst the radius $R = DB$ of the arc described by the driving pin of the expansion link, together with the radius $r = OA$ of the return crank pitch circle, are chosen such that the maximum angle of swing about the central position of the expansion link is sufficient to give the required valve port openings in full gear. Movement of the expansion link about its pivot D is defined by the angle $D'D\,D''$, where the line DD'' is tangential to the curved centre-line DJ of the expansion link at the pivot D and the line DD' defines the position of the line DD'' when the link is in its central position. The orientation of the line DD' is in turn defined by the angle KDD' which corresponds to the angle of inclination MDN of the radius rod when in mid-gear on account of the kinematic symmetry required of the valve gear in forward and reverse motion. Whilst this last angle may be chosen, at least to some extent, the choice must be such that the kinematic requirements of the lap and lead motion derived in conjunction with the combination lever, the crosshead drop link, and the crosshead anchor link are also satisfied.

Fig. 3 shows details of the expansion link geometry and the required back-set is specified by the angle BDD'', although the radial distance X from the intersection J of the two arcs DJ and BJ to the driving pin B may be preferred as a dimension for marking out and construction and this may be determined when the length $MD = M'D = h$ of the radius rod is known as it would be in all practical cases.

Analytical method

The table shows the various formulae which arise in calculating the expansion link driving pin back-set and eccentric rod length. The variables of the motion are the two angles AOT and $D'D\,D''$, (Fig. 2), and these are related by the two equations (1) and (2) which may be combined as indicated in equation (3). Equation (3) can also be determined directly from triangle ABG. An application of the differential calculus leads to equation (4) which shows, as is physically obvious, that the extreme angles of swing of the expansion link about its cent-

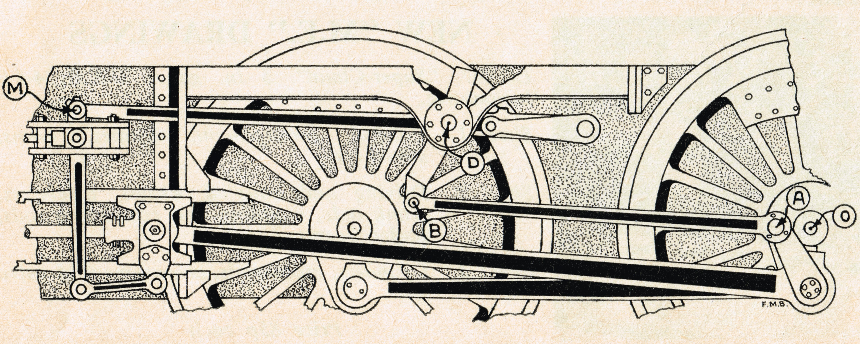


Fig. 1: Layout of a typical Walschaerts valve gear, for inside admission valves.

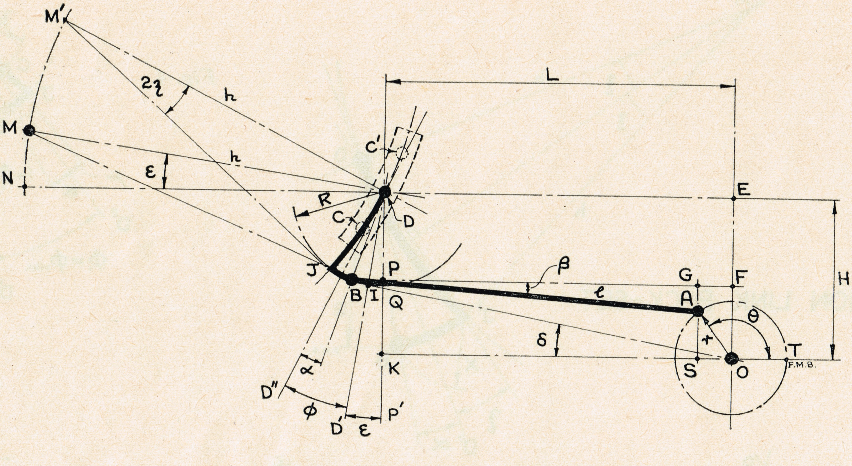


Fig. 2

LINKAGE DIAGRAM

TABLE OF EQUATIONS & FORMULAE.

FROM FIG. 2. VARIABLES OF MOTION ARE θ & ϕ.

$$L = OK = FG + GP = FG + GB - BP,$$

$$\underline{L = \ell\cos\beta - r\cos\theta - R\sin(\phi+\varepsilon-\alpha),} \tag{1}$$

$$H = OE = OF + FE = SA + AG + PD,$$

$$\underline{H = \ell\sin\beta + r\sin\theta + R\cos(\phi+\varepsilon-\alpha).} \tag{2}$$

ELIMINATING β BETWEEN (1) & (2),

$$\underline{\ell^2 = \{L + r\cos\theta + R\sin(\phi+\varepsilon-\alpha)\}^2 + \{H - r\sin\theta - R\cos(\phi+\varepsilon-\alpha)\}^2.} \tag{3}$$

DIFFERENTIATE (3) WITH RESPECT TO θ AND TAKE $d\phi/d\theta = 0$ FOR EXTREMA OF ϕ;

$$\tan\theta = -\{H - R\cos(\phi+\varepsilon-\alpha)\}/\{L + R\sin(\phi+\varepsilon-\alpha)\}, \text{ OR}$$

$$\underline{\tan\theta = -OF/BF = -\tan\beta \text{ AT MAX}^{\text{M}}/\text{MIN}^{\text{M}}\ \phi.} \tag{4}$$

AT EXTREMA OF ϕ,

$$\left.\begin{array}{l} \theta = \theta_1 = \pi - \beta_1, \quad \phi = \phi_1, \\ \& \quad \underline{\theta = \theta_2 = 2\pi - \beta_2, \quad \phi = \phi_2.} \end{array}\right\} \tag{5}$$

FOR EQUAL MAX$^{\text{M}}$ ANGLES OF SWING,

$$\underline{\phi_2 = -\phi_1.} \tag{6}$$

PUTTING (5) & (6) IN (1) & (2) IN TURN AND ELIMINATING THE ANGLES β_1 & β_2,

$$\underline{(\ell+r)^2 = L^2 + H^2 + R^2 + 2R\{L\sin(\phi_1+\varepsilon-\alpha) - H\cos(\phi_1+\varepsilon-\alpha)\},} \tag{7}$$

$$\underline{(\ell-r)^2 = L^2 + H^2 + R^2 - 2R\{L\sin(\phi_1-\varepsilon+\alpha) + H\cos(\phi_1-\varepsilon+\alpha)\}.} \tag{8}$$

PUTTING $\underline{\gamma = \varepsilon - \alpha}$, (9)

THEN ON ADDING AND SUBTRACTING (7) & (8),

$$\underline{\ell r = R\sin\phi_1\{L\cos\gamma + H\sin\gamma\},} \tag{10}$$

$$\& \quad \underline{\ell^2 + r^2 = L^2 + H^2 + R^2 + 2R\cos\phi_1\{L\sin\gamma - H\cos\gamma\}.} \tag{11}$$

ELIMINATING ℓ BETWEEN (10) & (11),

$$\underline{(R/r)^2\sin^2\phi_1\{L\cos\gamma + H\sin\gamma\}^2 + r^2 = L^2 + H^2 + R^2 + 2R\cos\phi_1\{L\sin\gamma - H\cos\gamma\}.} \tag{12}$$

INTRODUCE THE GEOMETRIC CONSTRAINT

$$\underline{R\sin\phi_1 = r}, \quad \text{(FIG. 4)}, \tag{13}$$

THEN (12) BECOMES, ON SOLVING FOR γ,

$$\underline{\sin\gamma = \sqrt{(1+a)(1-a)(1+b)(1-b)} - ab,} \tag{14}$$

WHERE $a = L/D$, $b = d/D$, $D = \sqrt{L^2+H^2}$, & $d = R\cos\phi_1$.

HENCE, FROM (9) & (14),

$$\boxed{\text{BACK-SET ANGLE } \alpha = \varepsilon - \gamma.} \tag{15}$$

PUTTING (13) IN (10),

$$\boxed{\begin{array}{l} \text{ECCENTRIC ROD LENGTH } \ell = L\cos\gamma + H\sin\gamma \\ \text{OR} \quad (\ell/D) = a\cos\gamma + \sqrt{(1+a)(1-a)}.\sin\gamma \end{array}} \tag{16}$$

FOR THE BACK-SET DISTANCE X, (FIG. 3),

$$\underline{X = BJ = 2R\sin\left(\frac{\zeta+\alpha}{2}\right),} \tag{17}$$

$$\text{OR} \quad \underline{X = R\sqrt{2\{1-\cos(\zeta+\alpha)\}},} \tag{18}$$

$$\text{WHERE} \quad \underline{\sin\zeta = (R/2h).} \tag{19}$$

SPECIAL CASE; WHEN $\varepsilon = \delta$ (FIG. 2),

$$\underline{\sin\varepsilon = \sqrt{(1+a)(1-a)(1+m)(1-m)} - am,} \tag{20}$$

WHERE $m = R/D$.

tral position occur when OA is aligned with AB. Corresponding to these extremes are the angles (5) and for the maximum angles of swing of the expansion link to each side of the central position to be the same as one another the relation (6) must hold. On putting this information into equations (1) and (2) and eliminating the angle ABG, equations (7) and (8) are obtained and these in turn can be added and subtracted to give the results (10) and (11). Elimination of the eccentric rod length l between (10) and (11) then leads to the general result (12).

For the proper working of the valve gear, the positions A of the return crankpin corresponding to the extreme forward and rearward positions of the expansion link driving pin must be at opposite ends of a diameter through O of the return crank pitch

Fig. 3

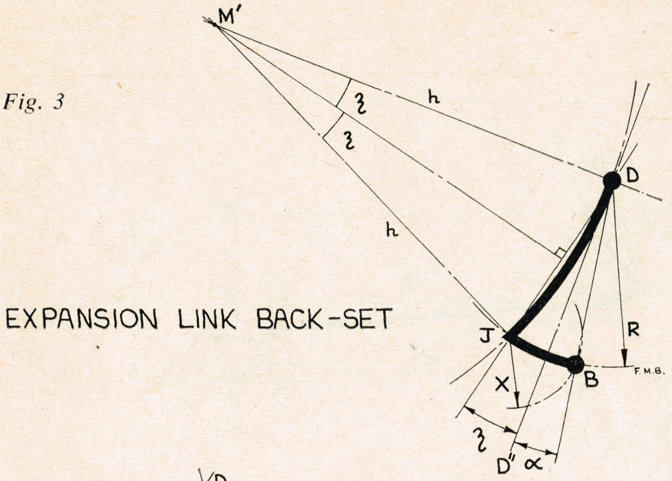
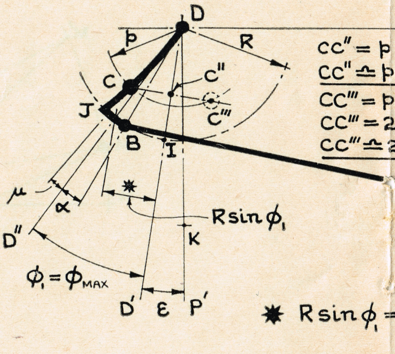
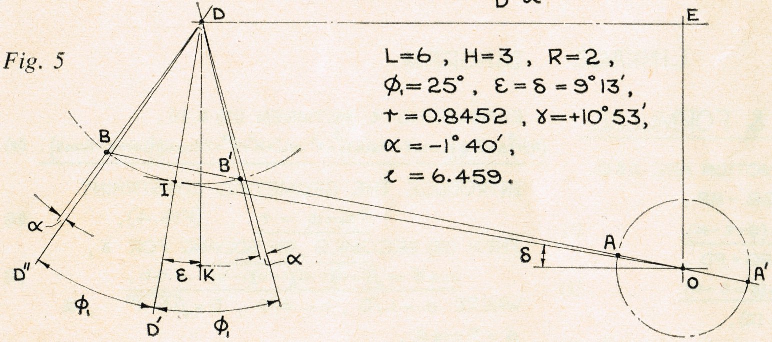

EXPANSION LINK BACK-SET
M′
h
ζ
ζ
h
D
J
B
R
X
ζ
D″ α
F.M.B.

Fig. 4


D
p
R
CC″ = p
CC″ ≏ p
CC‴ = p
CC‴ = 2
CC‴ ≏ 2
C
C″
C‴
J
B
I
μ
α
R sin φ₁
K
D″
φ₁ = φ_MAX
D′ ε P′
✸ R sin φ₁ =

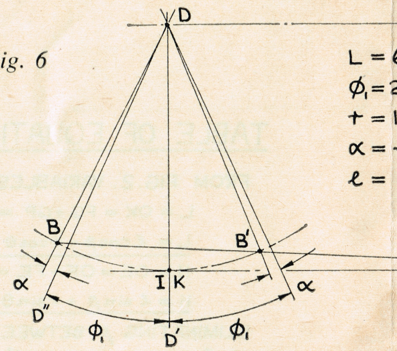
GEOMETRIC C

Fig. 5


D
E
L=6 , H=3 , R=2 ,
φ₁=25° , ε=δ=9°13′,
t=0.8452 , γ=+10°53′,
α=−1°40′,
ℓ=6.459.
B
B′
I
α
A
δ
O
A′
D″
ε K
α
φ₁
D′
φ₁

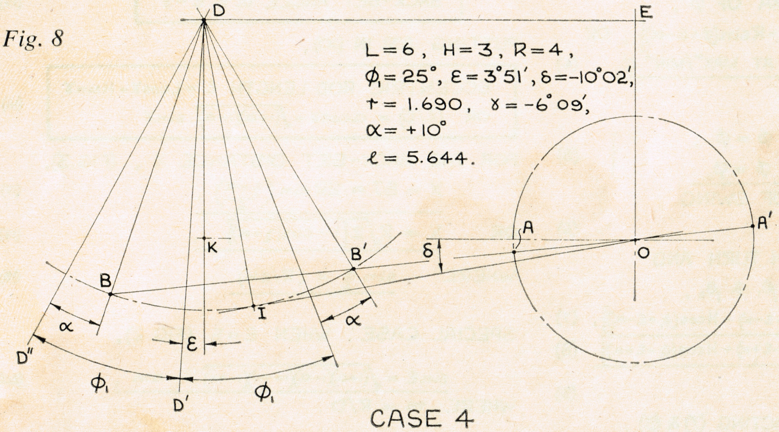
CASE 1

Fig. 6


D
L =
φ₁ =
t =
α =
ℓ =
B
B′
α
I K
α
D″
φ₁
D′
φ₁

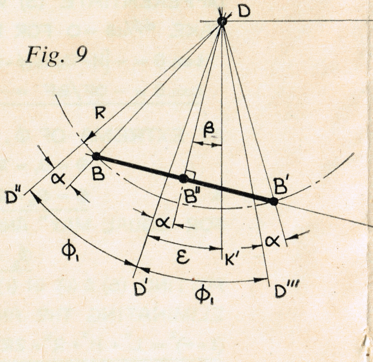
CAS

Fig. 8


D
E
L=6, H=3, R=4,
φ₁=25°, ε=3°51′, δ=−10°02′,
t= 1.690, γ= −6°09′,
α= +10°
ℓ= 5.644.
K
B′
δ
A
A′
O
B
I
α
α
ε
D″
φ₁
D′
φ₁

CASE 4

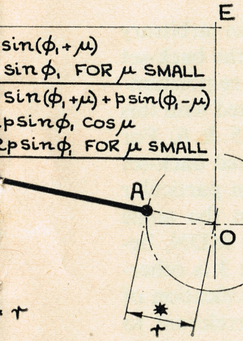
Fig. 9


D
R
β
B
α
D″
B″
B′
α
α
ε
K′
φ₁
D′
φ₁
D‴

GEOMETRIC C

circle. This is a necessary condition for equal times of movement of the return crankpin along either the upper or lower portions of the return crank pitch circle between these two extreme positions at constant driving wheel speed. It follows, therefore, that since the maximum forward and rearward positions of the expansion link occur when OA is aligned with AB the corresponding angles ABG are the same for both cases. On putting this information, together with (5) and (6), into equations (1) and (2) it can be shown easily that the geometric constraint (13) must be satisfied and that the angle ABG, (Fig. 2), must be equal to the auxiliary angle (9), used in developing the various formulae, when the expansion link is in the extreme forward and rearward positions.

When the geometric constraint (13) is imposed the solution of (12) can be obtained in the very simple


E
sin(φ₁+μ)
sinφ₁ FOR μ SMALL
sin(φ₁+μ)+psin(φ₁−μ)
psinφ₁ cosμ
2psinφ₁ FOR μ SMALL
A
O
F.M.B.
*
r
r

ONSTRAINT

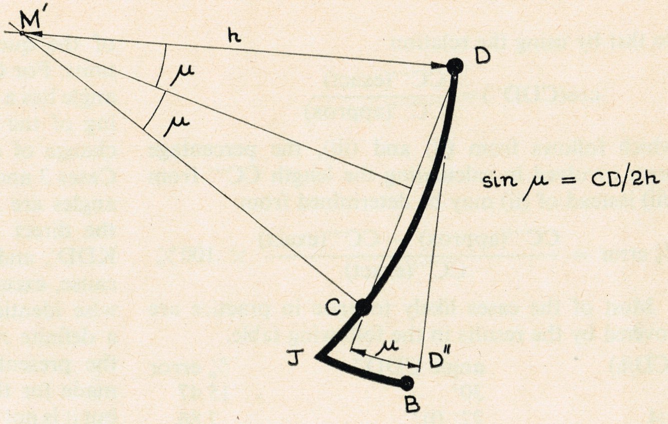
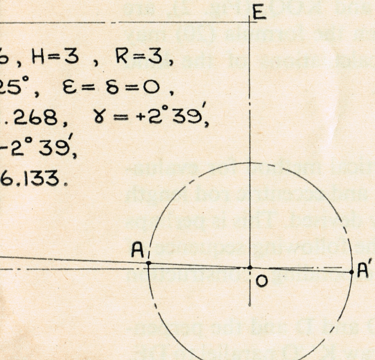

M′
h
D
μ
μ
sin μ = CD/2h
C
J
μ
D″
B

Fig. 4A


E
, H=3 , R=3,
25°, ε=δ=0,
.268, γ=+2°39′,
−2°39′,
6.133.
A
O
A′

SE 2

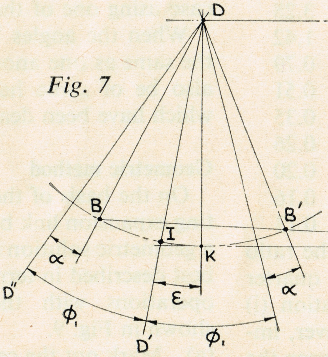
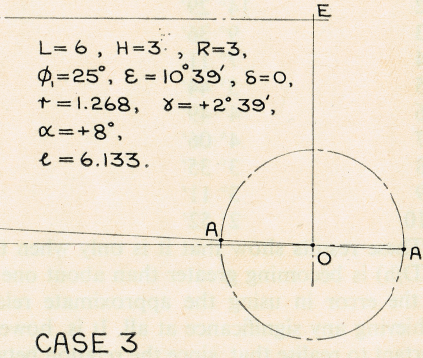
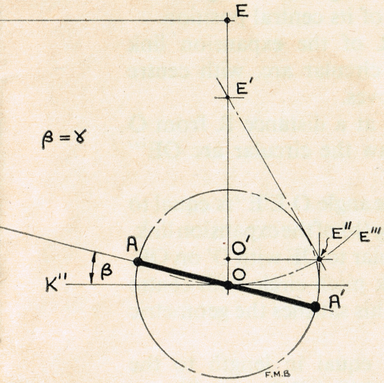

D
B
B′
I
K
α
α
D″
ε
φ₁
φ₁
D′

Fig. 7


E
L=6 , H=3 , R=3,
φ₁=25°, ε=10°39′, δ=0,
r=1.268, γ=+2°39′,
α=+8°,
ℓ=6.133.
A
O
A′

CASE 3


E
E′
β=γ
E″ E‴
A
O′
O
K″
β
A′
F.M.B

ONSTRUCTION

terms indicated in (14). From this both the back-set angle BDD″ and the eccentric rod length follow at once and are given by (15) and (16). In deriving these solutions only the positive values of the square-roots have been considered as it is only these positive values which are relevant to the present discussion. When the length MD of the radius rod is known the back-set distance X, shown in Fig. 3, may also be determined and two equivalent formulae for this, both of which are easily derived from Fig. 3, are quoted in (17) and (18). For some valve gear arrangements the back-set angle may take negative values but the corresponding back-set distance X is always positive as long as the angle JDD″, (Fig. 3), given by (19), is numerically larger than the back-set angle. All of the results derived in the foregoing are mathematically exact.

In designing the layout of Walschaerts valve gear it seemed to be fairly common practice to calculate the return crank pitch circle radius r from the approximate relation

$2\ p\ r = R$ x valve travel in full-gear, (i)

where the required valve travel is at most equal to, if not somewhat less than, the dimension CC‴ in the notation of Fig. 4. Because the radius MD=h of the expansion link is relatively large compared with the length CD, the angle CDD″, between the die-block pin C in full-gear and the expansion link tangent line DD″, is usually very small so that the dimension CC‴, given exactly by

$CC'''(\text{exact}) = 2\ p\ \sin(D'D\ D'')\ \cos(CDD''),$ (ii)

is approximated quite closely by

$CC'''(\text{approx}) = 2\ p\ \sin(D'D\ D''),$ (iii)

When this approximation is made the relation (i) reduces to the geometric constraint (13). The amount of error involved in the approximation is easily evaluated. Clearly, from Fig. 4, the angle CDD″ may be deduced from

$$\sin(CDD'') = (CD/2h),$$

so that by using the relation

$$\cos(CDD'') = \frac{CC'''(\text{exact})}{CC'''(\text{approx})}$$

which follows from (ii) and (iii), the percentage error involved in calculating the length CC‴ from (iii) instead of (ii) may be determined from

$$\%\ \text{error} = \frac{CC'''(\text{approx}) - CC'''(\text{exact})}{CC'''(\text{exact})} \times 100\%$$

Most of the cases likely to arise in practice are covered by the results in the following table.

(CD/h)	angle CDD″	% error
1	30°	15.47
3/4	22° 01′	7.86
1/2	14° 29′	3.28
1/3	9° 36′	1.42
1/4	7° 11′	0.79
1/5	5° 44′	0.51
1/6	4° 49′	0.35
1/7	4° 06′	0.26
1/8	3° 35′	0.20
1/9	3° 11′	0.16
1/10	2° 52′	0.13

These results show that it is only when the ratio (CD/h) is becoming greater than about one quarter is the error in using the approximate relation (i) achieving any significance at all. It is, however, important to realise that, since the relation between the return crank pitch circle radius r and the expansion link driving pin radius R is in fact fixed by the exact requirements of the geometric constraint (13), the approximate relation (i) is, in the strictest sense, only of use in determining the length p = CD, (Fig. 4), necessary for the required valve travel in full-gear.

The formulae (14) and (15) show the dependence of the back-set on the lengths L, H and d, and on the angle of inclination KDD′, (Fig. 2), of the expansion link when in its central position, and also therefore on the angle of inclination MDN, (Fig. 2), of the radius rod when in mid-gear. This angle of inclination makes a direct and most significant contribution to the expansion link driving pin back-set and a very striking example of this is to be found on the preserved British Railways Class 9F 2-10-0 *Evening Star*. The very steeply inclined radius rods of this locomotive give rise to a substantial back-set of the driving pins on the expansion links.

Four examples of back-set angle and eccentric rod length have been worked out so as to demonstrate the theory. These numerical results are shown, together with the relevant arbitrarily chosen starting values L, H, R, the angle KDD′, and the maximum angle of swing of the expansion link, in Figs. 5 – 8 which have been drawn accurately to proper scales. In these figures, the points A′ and B′ correspond respectively to the back-swing positions of the return crankpin and the expansion link driving pin and all of the quoted linear dimensions are in arbitrary units. For Cases 1 and 2, (Figs. 5 & 6), the back-set angle has a negative sign and the relative re-positioning of the lines DB and DD″ associated with this change of sign is made clear in Figs. 5 & 6. For Cases 3 and 4, (Figs. 7 & 8), the calculated back-set angles are positive and Case 3 shows in particular the direct dependence of this angle on the angle KDD′, and also therefore on the angle MDN, because, except for the angle KDD′, Case 3 is otherwise identical to Case 2. Since the specification of a definite radius rod length is strictly irrelevant to the present discussion no calculations have been made for the back-set distance X shown in Fig. 3 but it is not difficult to evaluate this for any particular case using one of the formulae given.

When the angles KDD′ and KOQ, (Fig. 2), are the same as one another then the formula (20) may also be of some help in calculations of the kind which have been dealt with.

Geometric method

On the basis of the analytical method for evaluating expansion link back-set and eccentric rod length a geometric solution is easily devised. This is perhaps best described in terms of the following sequence of operations with the corresponding construction shown in Fig. 9.

(a) Mark out the centres O and D and the perpendicular lines DE and OE. Draw K′ ′O parallel to DE.
(b) Choose the maximum angle of swing of the expansion link to one side of its central position.
(c) Choose the radius R of the expansion link driving pin and draw the circular arc, with centre at D, on which this pin moves.
(d) Mark the position E′ at a distance R from O along the line OE and draw the circular arc OE‴ of radius R.
(e) Draw E′E″ such that the angle O E′E″ is equal to the maximum angle of swing (b) of the expansion link.
(f) Draw O′E″ perpendicular to OE with O′ on OE.
(g) Draw the return crank pitch circle with centre at O and of radius O′E″. (This satisfies the geometric constraint (13).)
(h) Draw the chord BB′ equal in length to the diameter AA′ and such that A′O A B′B are collinear. (This fixes the angle K″O A).
(i) Draw the lines DD′, DD″ and DD‴.

Then,

back-set angle = angle D″D B = angle D′D B″ = angle D‴D B′,

and

eccentric rod length = AB = A′B′ = OB″.

Because of the oblique intersection of the chord BB′ with the circle of radius R centred at D it is rather difficult to perform the operation (h) with accuracy. It is precisely this kind of difficulty which the analytical method overcomes so admirably.

MODEL LOCOMOTIVE CONSTRUCTION FOR BEGINNERS

Part XVII

by Martin Evans

From page 710

Coupling and Connecting Rods

LOOKING THROUGH my recent articles under the heading "Model locomotive construction for beginners", I notice that I have not so far said anything about coupling and connecting rods. So let us now take a look at these interesting locomotive details.

Many of the earlier locomotives were fitted with coupling rods having individual adjustment at the bearings, using separate "brasses" and a taper cotter and push-plate or "glut", the bearing ends of the rods, and the intermediate parts of the rod if the engine was six or eight-coupled being of rectangular shape. With the improvement in bearing metals, however, the plain bush gradually superseded the more complicated arrangement. Hard bronze of about ½ in. thickness, plus about 3/16 in. thickness of white metal was usual in British practice. The bush was generally secured by a rectangular key, though in some cases (the L.N.E.R. A.4 class for instance) a set screw was used in addition.

Floating bushes were sometimes used in full-size practice, especially in the U.S.A., where the bushes were usually in three sections with 1/32 in. cuts between each segment to allow for expansion.

In some cases, the distance between the coupling rod centres was made slightly greater than that between the centres of the coupled axles, 1/32 in. being an average amount; this was done to allow for the effects of strains arising in the frames when loaded and also for expansion due to heat radiated from the firebox when this was adjacent to the coupled wheelbase. Allowance for this was made in the diameter of the bushes.

On most modern locomotives, the coupling rods were fluted very deeply both front and back, an extreme case being the L.N.E.R. A.4 and other classes where the section of the rods was 5 in. x 2½ in., yet the thickness of the web was only ⅜ in. This was made possible by the use of high grade nickel-chrome steel. Even so, full size coupling rods were heavy items, the weight of the A.4 class rods being 463 lb. per side.

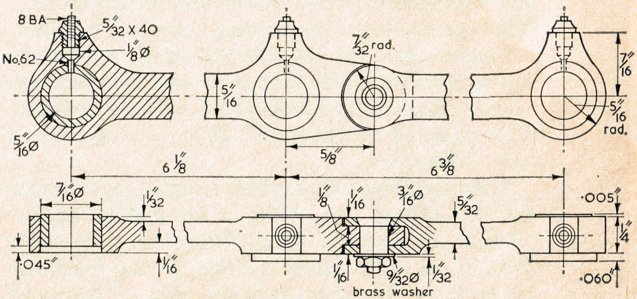
Some railways, especially those which had curves of rather small radius, specified an additional joint in the coupling rods having a vertical pivot. The trailing bearing of the rods of the Great Eastern "1500" 4-6-0's were of this type.

Most model engineers use ordinary bright mild steel for coupling rods, it being considered hardly worth while going to the extra expense of some kind of stainless steel, which is considerably harder to machine in some cases (K.E. 40A or stainless-iron is fairly easy to work). Stainless is however rather nice for an engine intended for exhibition.

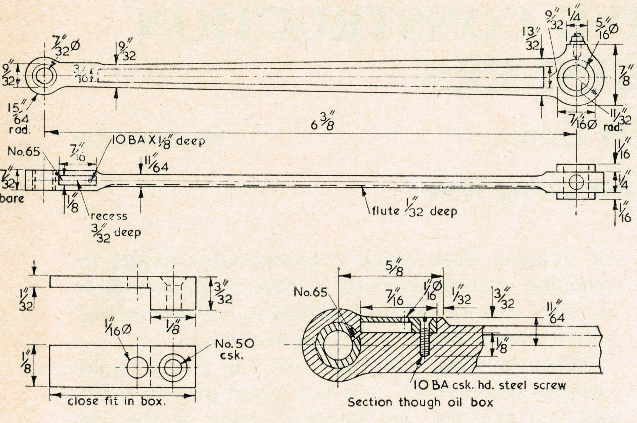
When making coupling rods for six or eight coupled locomotives, it is not a bad plan to mark out and drill for the "knuckle" joints in the rod blanks before marking out the centres of the crankpins. These joints can in fact be finished off, using either a plain case-hardened pin working direct in the rod, or a press-fitted bronze bush being used. The blanks can then be dismantled again for the remaining machining and finishing operations.

One way of ensuring that the coupling rods are of the right centres to suit the engine is to first drill and ream them an exact fit for the crankpins and try them on the locomotive. If they won't go on at all, it should be evident where they are "out"; if they do go on, but with a tight spot on rotating the wheels, a bright mark will quickly show up where the rod is tight; the hole can then be drawn over with a round file, then re-drilled and finished off ready for the bushes, which are best made a good press fit. The bushes are afterwards opened out to suit the crankpins. It is advisable to make the bushes on leading or trailing crankpins a fairly easy fit, but the bush on the driving crankpin can be a close working fit.

For shaping the outsides of coupling rods, a horizontal milling machine is ideal for removing the quite considerable amount of metal, though if a substantial vertical-slide is available, nearly all the machining can be done in the average model engineer's lathe. A length of stout steel angle about 2 in. x 2 in. x ¼ in. should be obtained, several inches



COUPLING RODS FOR A ¾″ SCALE ENGINE



L.M.S. TYPE OUTSIDE CONNECTING ROD

longer than the longest coupling (or connecting) rod likely to be dealt with, and this is bolted to the vertical-slide which is set up facing the lathe spindle. The angle can be brought up to the lathe faceplate to ensure that it is square across the lathe axis, and to ensure that it is also truly horizontal, it can be traversed across a short rod held in the chuck and feelers used; better still a d.t.i. can be set up on the lathe bed or attached to the faceplate, and the cross-slide traversed right across, through its full travel.

As much commercial steel angle is not exactly at 90 deg. a very light cut may be required, across the whole of the upper, working face of the angle before commencing operations.

The rod is held down to the angle by a suitable bolt and washer through its bearing holes, into tapped holes in the angle, and the machining can be done by a small face cutter, a small side-and-face cutter, or a Woodruffe cutter, according to the size of the rod.

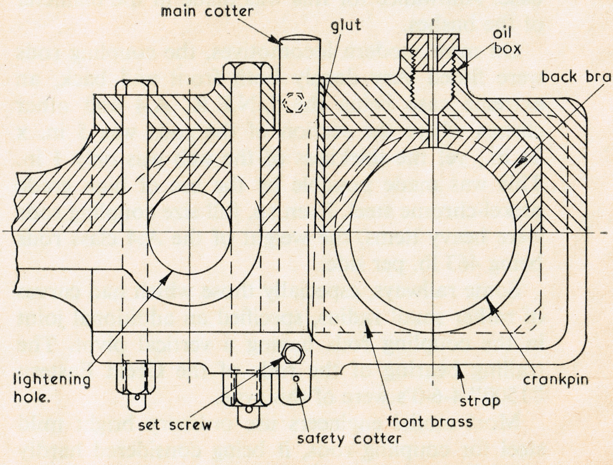
If the coupling rods are required fluted, it is probably best to cut the flute to the full depth first, then follow up by milling right across the face of the rod, for its full width, then mill on each side of the flute. By this method, it is easy to see that the flute is exactly in the centre.

Although much fluting of model rods is done with standard cutters, these will inevitably leave the flute with square corners, which is not strictly correct. If the correct flute with radiused corners is required, the cutter used for the job will have to have its cutting teeth radiused off on both sides, an operation which really calls for a proper tool and cutter grinder, if the essential "backing off" of the cutting teeth is to be achieved.

Some coupling rods for four-coupled locomotives are "fish-bellied", i.e. wider in the middle than at the ends. In this case, it is probably best to machine them to the width across the middle, and finish the job by filing. The shaping of the radiused ends and the oil boxes sometimes presents difficulties. My usual method is to drill series of holes, about 3/32 in. dia. in a 5 in. gauge rod, all around the ends and the oil box, but just outside the scribed line. If the holes are carefully spaced, not quite touching one another, and not too close to the scribed line, a drill a little larger can be used until all the holes break into one another, when the unwanted metal can be broken away. The job is then taken a stage further by filing, leaving a few thou to be removed by the final operation, which is done in the lathe.

A length of square brass (½ to ⅝ in.) is set up in the four-jaw chuck and one end is turned to a good fit in the holes in the coupling rod, for a length slightly greater than the thickness of the rod. This is then firmly clamped under the lathe tool-holder, and set exactly parallel to the longitudinal axis of the lathe. A small end mill is then held by chuck or collet and the coupling rod swung by hand against it, using a medium speed and very careful feed. The rod must of course be swung against the rotation of the end mill, otherwise it will "catch up" and spoil the job. The rod should be held very firmly by the hand (an old glove is advisable in case of any sharp edges left by previous machining) and if the rod is small, a large toolmaker's clamp can be used, to give a better grip and better control as the rod is swung. No-one need be ashamed to use emery cloth to finish off coupling and similar rods; in any case, no sharp edges should be left—sharp edges, as left by the machine, are never left on full-size rods, and they should not be on our models.

A tip for beginners using end mills in the lathe. End mills have a nasty habit of working out of the three-jaw chuck, or even out of a correct-size collet. To avoid this, Clarksons make a special "Auto-lock" chuck, into which a threaded type of end mill is screwed. But these are expensive things, and a good substitute is to use the four-jaw chuck. True, this

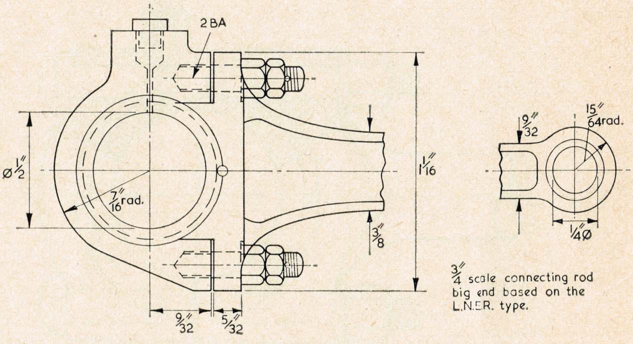


INSIDE CONNECTING ROD BIG END L.M.S. TYPE needs a d.t.i. and a good deal of patience to get the end mill running true, but the extra jaw holds the end mill much more firmly than the three jaws of the S.C. chuck.

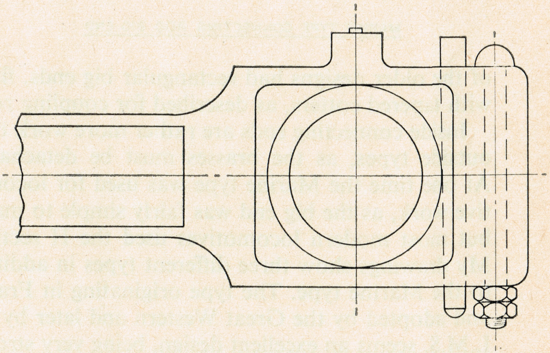
A common problem when fluting coupling and similar rods arises when the flute is cut on one side only—the rod warps badly. This is not so bad in the smaller scales, where the rod can generally be bent back again by hand; but in the larger 5 in. gauge rods, and certainly in 7¼ in. gauge and above, it is not at all easy to bend the rods straight again, as I have found to my cost. I am inclined to think that it is worth going to the trouble of fluting both sides (which is after all only correct practice) when the warping is no great problem, and if bending is required afterwards, it is a much easier job.

Another problem which arises with six and eight-coupled locomotives is how to deal with the leading crankpin and its retaining collar, as in most designs there is very little clearance at this point for the connecting rod.

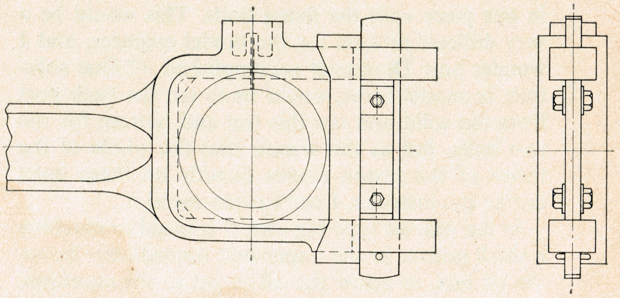
The usual solution is to recess the end of the coupling rod, and fit a thick flush washer, the crankpin being drilled and tapped for almost its full length, and a long countersunk screw used. A hexagon-socket type countersunk screw is probably best, being stronger than the ordinary commercial screw. It has been suggested that on the right-hand side of the locomotive, the thread used should be left hand, so that the friction of the coupling rod revolving around it does not tend to slacken it, with disastrous results. But I don't think this should be necessary. It might however pay to make up a special screw, perhaps in stainless steel, a shade oversize, which will be a really tight fit. Did someone say—"why not use Loctite?" Well that would certainly prevent the screw from coming out, but supposing one needs to take the coupling rod off for some reason or other, or merely to re-bush the rod?



¾ scale connecting rod big end based on the L.N.E.R. type.



A SIMPLE OUTSIDE CONNECTING ROD BIG END FOR SMALL LOCOMOTIVES



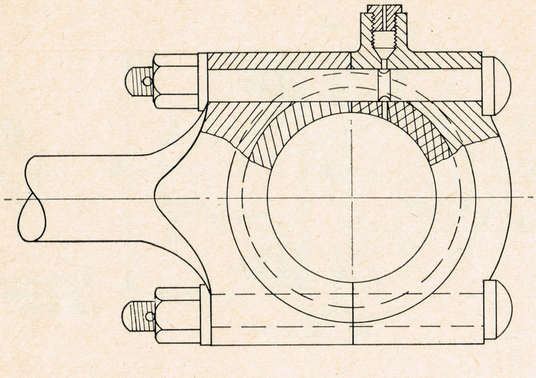
ANOTHER TYPE OF INSIDE CONNECTING ROD BIG END

Connecting rods

Nearly all my remarks about rods apply equally to connecting rods. However, connecting rods which are fluted nearly always require the flute to be tapered, as indeed are the sides. This can be done quite easily, using the vertical-slide and heavy angle as described. The rod is held down to the angle, as before, but a fitting bolt is used at the little end only. At the big end, a bolt considerably smaller than the bore of the rod is used. A light longitudinal centre line should be scribed right down the rod, and the rod lined up square to the lathe axis for the first cut, which can be made a few thou short of the final depth. The cutter is then returned to the small end of the connecting rod, the bolt in the big end slackened, and the rod slewed slightly to one side (by half the extra width required at the larger end of the rod) with the cutter still in the flute (the movement of the rod at the *small* end is so slight that no damage will be done to the cutter). Tighten the bolt at the big end.

Cut the full length of the rod again, returning the cutter to the small end. Slacken the bolt at the big end again and slew the rod an equal amount to the other side. (This can be gauged quite easily if little scriber marks are made on the rod and corresponding marks on the angle at the big end.) Proceed as before, when the flute will emerge correctly tapered. The same procedure can be used of course for milling the sides of the rod.

While most modern locomotives had plain rounded big ends on their outside connecting rods, some



MARINE TYPE CONNECTING ROD BIG END

of the older designs had rectangular big ends, fitted with tapered cotters, as described for coupling rods.

Inside connecting rods are rather more work than outside types, as the brasses must be detachable. At one time the Marine type was used for locomotive work, as the big end was fairly simple to make, but most modern locomotives used the H section. My drawings show three different types in addition to the Marine type. The type originating in France and adopted by the Great Western and later by the L.M.S. seems an excellent design, being very strong, yet lighter than the traditional British design while the Gresley type is probably the lightest of the lot, but certainly the hardest to make. In full-size, the strap of the Gresley big end was bent right round in one piece with the fixing bolts. This would be a very difficult process for the model engineer, and I wonder how Doncaster accomplished it? One solution, in model form, would be to cut the back part from the solid and tap this top and bottom for the two bolts, but as this means that the whole of the thrust of the piston comes directly on these bolts during the instroke, I can't recommend it.

In the Marine type big end, it is usual to machine a small groove in the upper bolt immediately below the oil box, to allow the oil to get to the crankpin. This will not materially reduce the strength of the bolt, as the threaded part of it is generally the weakest part. The bolts should be fitted with locknuts and split pins, or some kind of anti-vibration nut used in lieu.

It is often suggested that ball or roller bearings are worth while in the big ends of outside connecting rods, or possibly needle roller bearings. Needle rollers require the crankpin to be hardened; although it is possible to obtain needle roller bearings with inner "races", the snag here is the large diameter of the whole assembly, which rather spoils the appearance of the locomotive. Another problem of ball or roller bearings here is the fact that due to the locomotive being on springs, the connecting rod is not always working on a true line, its big end being continually subjected to a twisting motion as the axleboxes rise and fall in their horns. Probably the best solution if some form of rolling bearing is required is a double-row self-aligning ball bearing. This should be fitted with a cover to keep out dust and grit.

The lubrication of coupling and connecting rods should not be neglected. Full-size practice can often be followed without too much work, though with the much higher r.p.m. of the average model, causing the oil to be thrown about much more, I am inclined to think that a medium grade motor car grease would be better than oil, in which case, the oil box can be filled by hand, and then sealed with a plug made of cane, or if no cane is available, a cut-down match stick will probably suffice. The idea of the cane is of course to allow just enough air through to enable the lubricant to get to the journal, while at the same time preventing the entry of foreign matter.

SUPER-CLAUD

I have had several letters from builders of *Super-Claud* regarding the castings being supplied for the driving and coupled wheels. It is said that *Maid of Kent* wheels are not suitable on the grounds that the throw of the cranks is too small. I did not find this on my own locomotive, but if this is so, an easy solution is to reduce the throw of the cranks to suit the wheel bosses. As the engine is an inside-cylindered one, this will make no difference at all.

I understand that both "LocoParts" of Bristol and Blackgates Engineering of Wakefield, and I believe Wilwau Castings of Chesterfield, are supplying *Super-Claud* wheels with "swept-out" spokes and a thicker boss. This is quite correct, and builders wishing to use these can go ahead with confidence, but they must remember to extend their axles and crank-axles to suit!

TICH TIMES TWO

From page 866

is plenty of room in the cab. There are no burnt fingers and the water remains quite cool in the tanks due to the adequate lagging of the boiler. If she were made as a narrow gauge locomotive to run on 5 in. track, and I think this quite possible, almost all clubs throughout the country would be able to accommodate her.

Again my grateful thanks to Mr. C. H. A. Walker for the photographs provided.

TICH TIMES TWO

by W. J. Manley

I HAD BEEN waiting for a favourable day following the completion of my doubled up version of LBSC's 3½ in. gauge *Tich* described in the two May 1975 issues of *M.E.*, and to give *Lady Max* as she is called, her first steam trials.

So far I have only provided about 80 ft. of up and down multi-gauge track. That is a section of 3½ in. and 5 in. with another rail welded on to the outside at 2 in. spacing to give me a 7¼ in. track to run on. All the material is of 1 in. x ¼ in. black mild steel. Ultimately this section will be extended the full length of the garden, about 140 ft., and is almost straight on a gradient of approximately 1 in 80 rise. There is a little saucer-shaped dip at the lower end and that is where the lighting up, etc., takes place.

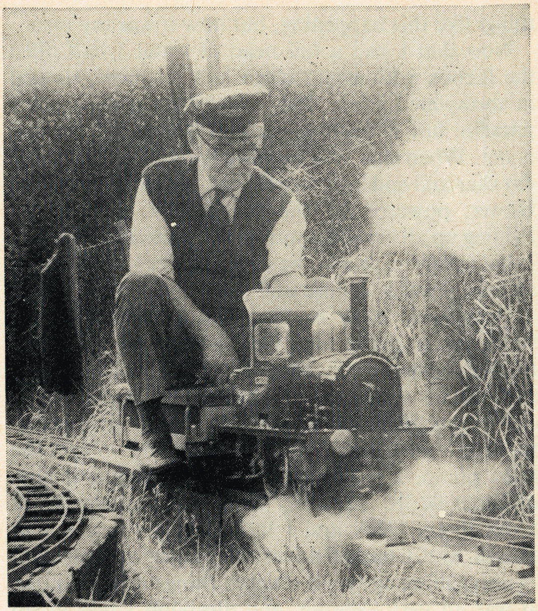
I now had to move the 140 lb of *Lady Max* from the workshop to the track. As I am a lone hand I use a two wheel transporter for the purpose. The transporter is fitted with a short length of 5 in. gauge track and on the top of this I bolted a piece of wood approximately 9 in. x 1 in. to stand *Lady Max* on. *Lady Max* and my 5 in. gauge locomotives are stored in the workshop on wooden platforms or stands, fitted with heavy castors, and are quite easy to move around.

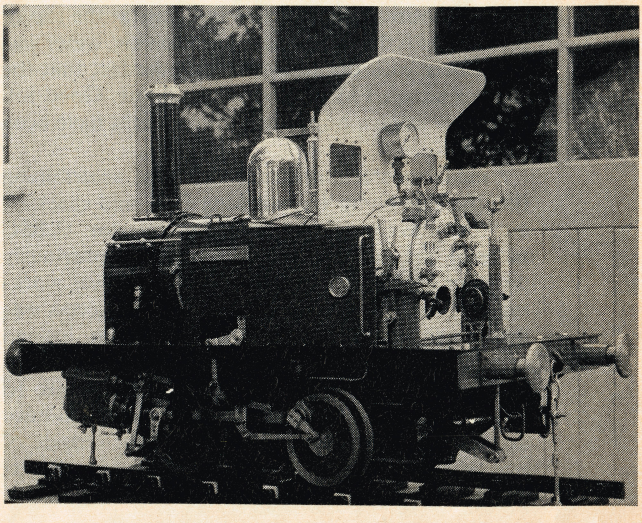
To move a locomotive out to the running track it is wheeled direct from the stand on to the transporter, the height being approximately the same. It is secured there on the transporter front and rear, either by the buffers or couplings, with a piece of sash cord. I now wheel the transporter into the garden, couple it up with a pin through the rail to my turntable. The turntable, which is situated just outside my running shed, is approximately the same height as my transporter, and the locomotive is wheeled from one to the other. No heavy lifting is required. As I have no 7¼ in. turntable on my up and down section of track, I raised it to the same height as the transporter and wheeled *Lady Max* off that way; again no heavy lifting.

So far, so good. Fuel, water and a car battery, to work the blower, together with a kit of tools, were gathered together at the starting position. As I had no 7¼ in. truck to ride on, I used one of my 5 in. gauge bogie wagons and because of the difference in height and width of the buffer beams, I introduced a sub section between them to compensate.

I was now all set to fill up with water and fuel. I usually fill up with water via the safety valve bush, but in this case, because the safety valve is within the dome, it was not possible. There was, however, a ¼ in. x 40 union spare on the whistle turret and to this I coupled a short length of copper tube with a small funnel on the top. I thought filling the boiler this way would be a slow job, but with the blower valve open to expel the air this was not so, or at least until I noticed that the water would rise no more than about ⅛ in. up the water gauge glass. Air was trapped in the top of the water gauge and on releasing the top water gauge nut I had ¾ glass.

It was obvious that I had omitted to drill a communicating hole from the top of the water gauge fitting into the boiler. To overcome this I drilled straight through the top square section of the water gauge fitting into the boiler and plugged the outside with a 3/16 in. x 40 hex. plug. I had read about





things like this happening, but now it was my turn.

Now that I had a full head of water I half filled the firebox with wood chips and charcoal, soaked in methylated spirit. This I find cleaner than using paraffin, but difficult to see if it is alight if the sun is out. When this was burning nicely I added more dry charcoal and later steam coal. My ex-government blower, powered by the car battery, is used for lighting up all my locomotives and stationary boilers. It has adaptors to suit the different sizes of chimneys and the draught is sure and gentle.

With about 20 lb. on the clock I noticed that the water gauge gland nuts were weeping a little and needed tightening up, also the glands in the blower and injector steam valves wanted adjusting.

At about 70 lb. on the clock the safety valve began to sizzle and I put in some more water to test the hand pump. The pressure was still rising and now at about 90 lb. the safety valve was blasting. It all seemed very lively and I looked at the fire. It was terrific, and I turned down the blower and pumped in some more water to quieten things down a little. It was all very exciting, and although I had lit up other locomotives before many times, this was the first time with this one and the first time is the one that is best remembered.

I injected some superheat steam oil into the steam chests, via the dummy tallow cups and gave the lubricator a twiddle or two.

Now that things had settled down a little, I opened the cylinder drain cocks and took my position rather apprehensively on the driving truck to focus my attention on the driving. I gingerly opened the regulator in full forward gear and moved off to a fine start, the cylinder drains discharging oily water on to the track. This soon turned to steam and I continued to the end of the track and back again.

I did notice that with half a glass of water, whilst the locomotive was standing in the saucer-shaped starting position, there was a full glass at the top of the run and if the safety valve was blowing, water was going over with the steam, despite the fact that the valve is situated in the top of the dome. Good job I was not using a pop valve, things might have been worse.

I made several more runs that day, ascertaining that the axle pump was working O.K. and checking on the injector. This particular injector (LBSC pattern) had dribbled a little when used previously on other engines, but now I found that it was working dry, over a good range. The greater success was due, I felt, to using a more direct 3/16 in. instead of 5/32 in. delivery pipe.

I had originally arranged for the hand pump to feed in to a tee on the injector delivery line, but have altered this since and it now feeds to the outside of one of the front delivery clacks. This is a Stuart Turner make and has a suitable inlet for this.

With only 4 in. driving wheels and only one passenger, myself, I had to use the hand brake to get a decent "chuff".

Despite my feelings whilst I was building, about having only just 60% cut-off in full gear, she starts beautifully in all positions of the driving wheels. No doubt a little reversing may be necessary with a big load behind her. I have seen the "Kings" and "Castles" do this when starting off in the good old days with about 12 or 14 on. Happy days, when I look back at them. Quite a thrill I used to get on platform 5 at Exeter St. David's station on a busy Saturday afternoon.

During my initial runs, I had a feeling that the lubricator was missing a beat or two at times, and I have since altered the angle of movement of the operating arm to correct this. The pawl seemed to rest on the top of the ratchet tooth.

It was a nuisance to have to open and close the cylinder drains after a lengthy stop and I tried some pressure operated ones I had by me. I set them carefully to release at 80 lb. They worked very well when the locomotive was in steam, but there was a snag. There was always water left over in the cylinders when they had cooled down and were giving me a mild hydraulic lock when pushing her along. This was not at all satisfactory and I have now fitted the usual lever operated ones, controlled remotely from the cab.

The whistle too had worried me a little. It was wet and woolly, despite the fact that it should have kept warm fixed as it was underneath the ashpan. I replaced it with another one in the same position, but that was no better.

A long time ago I modified a Boy Scout whistle, as suggested by LBSC, and tried it on several locomotives in the horizontal position, but I was never satisfied with it. I had been using it since mounted direct on the turret of a stationary boiler. On there it was always clear and dry. It was obvious that it had to be vertical. I have now fitted it in this position under the cab floor of *Lady Max* and it is 100%.

Lady Max had several runs during the remainder of the summer of 1975, and I must now extend the track to the maximum 140 ft. available. I feel it is a pity that my continuous track only covers 3½ in. and 5 in. and I would like one day perhaps to add a further rail to take 7¼ in. One trouble is that it is constructed from ¾ in. x ¼ in. flat steel with tubular spacers and ¼ in. bolts and the wheel flanges are quite deep on a 7¼ in. locomotive and hit the tubular spacers. Perhaps I can grind them away. With 1 in. x ¼ in. rail the spacers are lower and there is no problem.

Tich Times Two is in my opinion a nice size locomotive to construct. Nothing is very small to handle and it is quite powerful and docile to drive. There

Continued on page 864

An Experiment in Model Boiler Making

by Michael W. Smart

Boiler making is a subject of permanent controversy. There are those who delight in and others who dread the task. Both attitudes are an exaggeration of the work involved. The task is one with simple demands and a little care will ensure success.

Firstly, it is essential to have adequate heating when brazing large copper structures. These operations do not require ownership of large and expensive torches and bottles of gas. Today there are many hire firms who will produce the tools required for about £1.25 per day. By careful planning the hire period can be held down to a weekend and the whole boiler carcass brazed up in that time. A small lamp will do all the odds and ends for the rest of the model.

With carcass built up and low pressure tested it is time to stay. Here much argument will ensue. Do we use rivets and silver solder, or screwed stays and high temperature lead/tin sweating?

Personally I find faults with both. In the case of silver soldered stays the excessively prolonged heating can lead to grain coarsening of the sheets. The stays may become truly burnt, particularly if brazed in before the backhead and foundation ring are fitted. If they fail in service, difficulty is experienced in repair. It is my opinion that a silver soldered stay system is not as strong as the advocates of the technique believe because the materials are subject to metallurgical degradation.

Lead/tin high temperature solder certainly avoids the metallurgical problem and is to be recommended on that feature alone. However, it is a messy job of a hit and miss nature which frequently necessitates several attempts before success and a seal over all stays is achieved. In addition there is the minor irritation of screwing dry clean stays into dry clean plates when both are of copper or copper alloys. Many tales of seized or galled threads can be told.

A boiler stay is a tie bar between two plates. As such it should rely for its anchorages upon positive thrust faces, i.e. screw threads and nuts or formed heads. Use of a plain shear joint simply brazed and without any upset is bad practice.

The requirements of a stay suited to model boilerwork can be expressed as follows: Provide a positive anchorage abutment to restrain forces. Make a seal to retain fluid.

The technique can be similarly defined as: Stay to be simple, i.e. threaded from drawn rod—or—simply upset each end. If threaded, use locknuts to prevent attrition of stay by fire and to lock. Minimal heating to be employed to preserve material properties. If threaded a lubricant to be employed whilst running into carcass to prevent galling or seizure.

The writer prefers the old-fashioned screwed and nutted stay, but detests the messy job of sweating. Work frequently assists model engineering, so a leaf was taken from the firm's book of experience. Why not use an adhesive to seal the stays and use threaded type. Before the chorus of protestation becomes too vociferous let us look at modern adhesives.

Several materials are commercially available which will withstand temperatures up to 200°C—models rarely exceed 165°C. Some of the materials will accept the environment of hot water and steam. Many applications of such materials have operated for years on end in structures and mechanisms of prime importance as regards failure and safety. All we require in our model is a reliable caulking material which is easy to apply between the thread fit.

The field can be rapidly narrowed upon grounds of availability over the counter and material suitability to epoxy resin in the form of Araldite or Loctite. Both are suitable and just about equally so in our case. Checks on both materials involved a study of properties, a run through various test reports and contact with the manufacturers of Loctite for final confirmation of suitability, then work began.

Firstly my *Rob Roy* received treatment using Araldite. Perfect sealing of screwed and nutted stays ensued but the boiler had to be quite warm to the touch to make the resin penetrate the threaded gaps between stay and plates. After four years the boiler is still perfectly tight. The disadvantage of this method was found to be the problem of keeping the boiler clean whilst working and the general sticky state everything got into. Epoxides also detest grease and scrupulous cleanliness is essential for a good bond; at times this becomes difficult.

The next trial was with Loctite grade 40 using primer as the catalyst. This, after specimen tests, was incorporated throughout my 5 in. gauge Compound (MR) boiler. Success was 100%. No heating is required, the Loctite lubricates the stays, the catalyst spray keeps the work clean and the whole cures itself without further ado. Some 300 plus stays were drilled, tapped, stays threaded all fitted up in two mornings work one weekend (the wrist ache lasted a fortnight). 225 psi pressure test showed zero leakage.

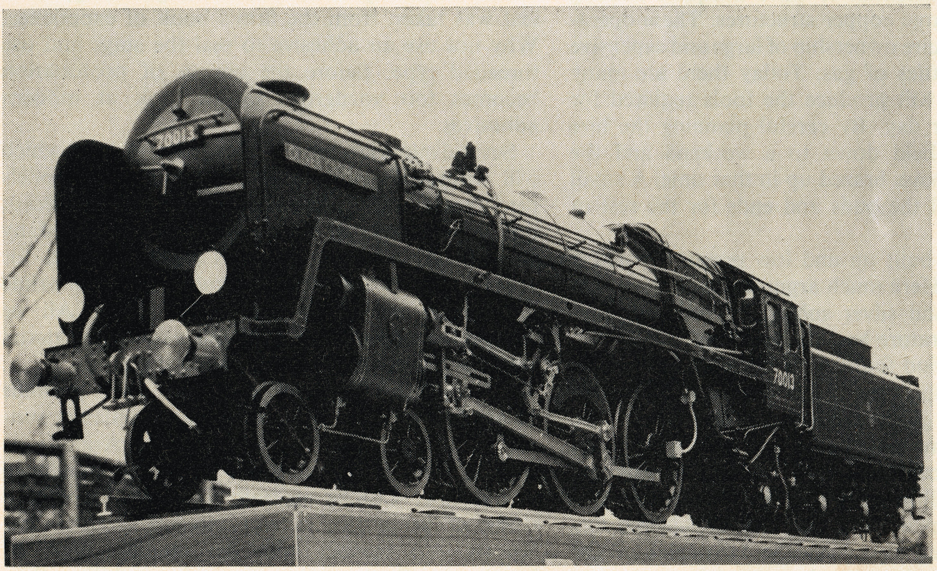
Continued on page 869

AROUND THE TRADE

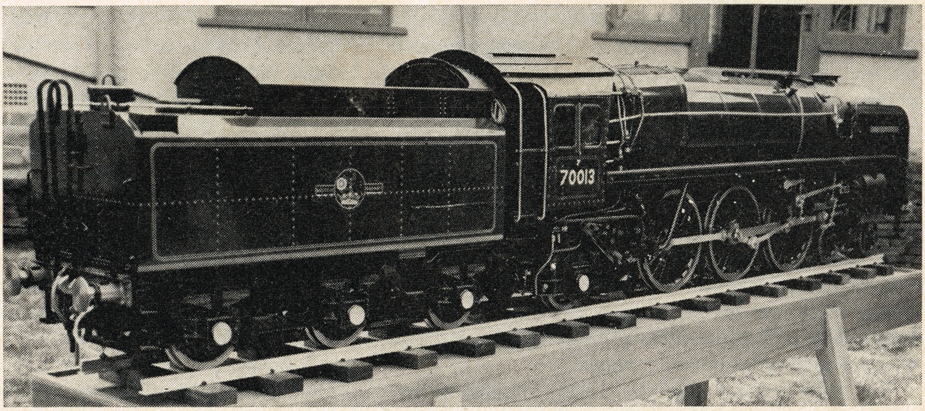
Castings by "Wilwau" (N. Spink, 52 Highfield Lane, Chesterfield).

This company supplies castings for many popular locomotives, including *Dot, Tich, Juliet, Rob Roy, Invicta, Doris, Jubilee, Evening Star, Britannia, Virginia, Titfield Thunderbolt, Speedy, Simplex, Pansy, Nigel Gresley, Torquay Manor* and many others.

A speciality of this firm is castings and drawings for 5 in. gauge *Britannia* and G.W.R. *King*.



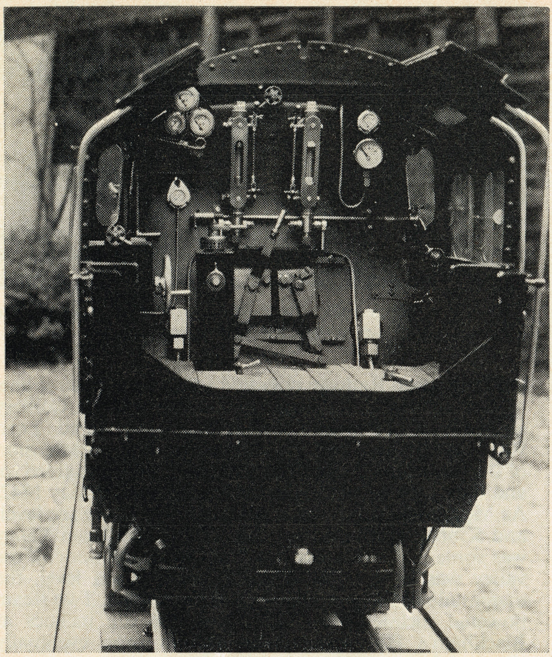
A 5 in. gauge 'Britannia' built by Mr. James Perrier using "Wilwau" castings.



A right-hand side view of the "Britannia".

A. J. Reeves & Co. Ltd., Holly Lane, Marston Green, Birmingham, B37 7AW.

Recent additions to the huge range of castings from Reeves include castings for *Asia*—5 in. gauge L.C.D.R. 2-4-0, *Ajax*—5 in. gauge 0-4-0T with Walschaerts valve gear, *Achilles*—5 in. gauge 0-6-0T—an extended version of *Ajax, Evening Star*—3½ in. gauge 2-10-0 by LBSC.



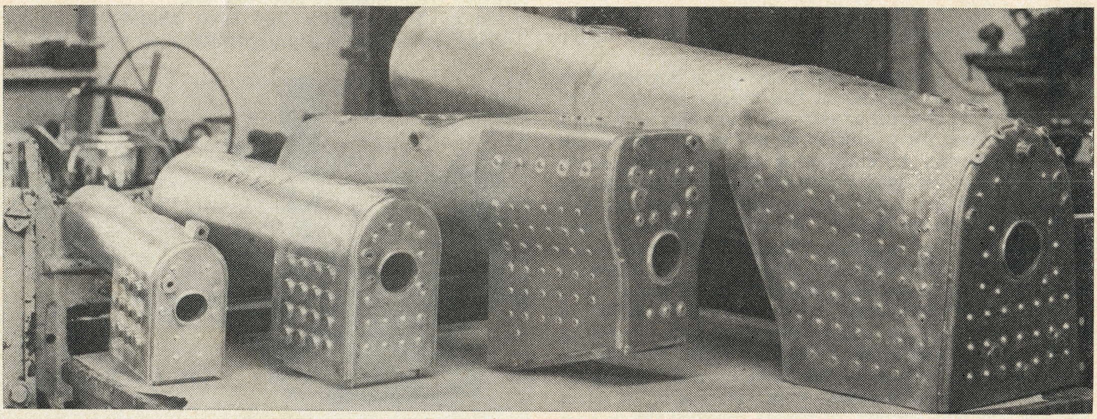
D. C. H. Bishop & Co. Ltd.
38 Hampstead Road, Handsworth,
Birmingham, B19 1DB.

This company specialises in all types of model boilers, in copper and silver-soldered throughout. Complete locomotives are also built and a range of boiler fittings.

We have recently received a selection of small boiler fittings for review. On the whole we consider these well made and finished, though we would prefer to see the handwheels in some other material than brass, which conducts the heat too much for comfort.

Left: Cab view of Mr. Perrier's 'Britannia'.

Below: Some boilers made by D. C. H. Bishop & Co.



BOILER MAKER

From page 867

Since then some 200 hours plus running have been built-up and 2 years gone by before the loco was stripped in March '76 for examination. The stays were bone dry save for one showing a pin head of lime build-up. The nut was run off, the surfaces of boiler and stay wire brushed and swabbed with Loctite primer. After this the nut was screwed back on with a spot of Loctite and pressure test showed all to be well.

A third boiler has just been completed by Keith Richardson of Cheltenham for his 48XX GW tank using the same method. This too was an immediate success and Keith is delighted.

The technique is as follows—clean boiler, drill for stays and clean again. Tap a row of holes, spray with Loctite primer and allow to dry. Prepare stays, prime, wet end with Loctite grade 40 hot strength, 601 or 602. Screw in stay, check for a green ring of Loctite at each surface between the threads and then fit the nuts each end. After about 20 minutes the stays and nuts are firmly bonded. Cleanliness is the essence of any engineering particularly when using adhesives, so dispense with all those dirty rags, etc. and use clean cloths or preferably paper wipers.

As a final word; it is reported that Loctite is not so good on copper as most other materials. This comment is true to a degree because the Loctite adheres to an oxide formed on the copper surface. Where used as a strength joint this point might be applicable. However, in the case of stays and nuts the Loctite itself is captive and acts only as a caulking and locking medium and we need have no fear.

For prospective followers of the method the materials used for 300 stays were 6 cc of Loctite with a lot left over and one can of primer spray. In terms of cost it works out about equal to Comsol solder required for an equivalent job. Most important is the reduction of misery normally encountered when staying.

JEYNES' CORNER

E. H. Jeynes on the "Bowes Railway"

THIS YEAR, another 150th anniversary of the opening of a railway is being commemorated. The railway started as the "Springwell Railway", and was later extended in stages, to reach a length of 15 miles, becoming the "Pontop and Jarrow Railway". In 1932 the title was altered to "The Bowes Railway"; it is to be remembered that the Queen Mother is a member of the Bowes family.

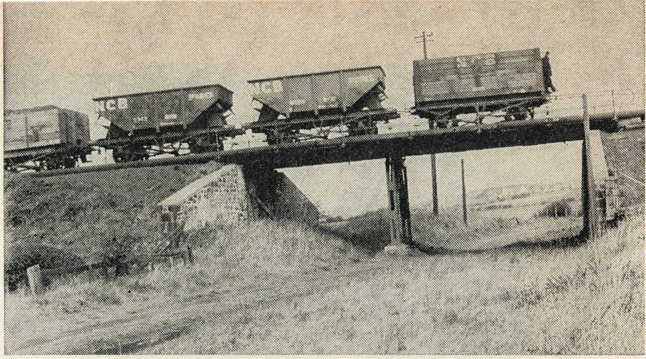
For almost a century, a powerful group of coal owners dominated the coal trade in the North East, and were known as the "Grand Allies": they had formed this partnership to combat the excessive charges demanded by landowners for wayleaves for the passage of coal over their land between the pits and the River Tyne. Among the collieries they owned was Killingworth where George Stephenson was employed by them, and had built his first locomotive in 1814, and Mount Moor colliery in County Durham which had been in production for nearly a century. Owing to the high ridge of land, this pit and the Tyne and falling ground almost all the way to the River Wear, a wagonway had been constructed to the upper reaches of this river.

The "Allies" started to sink a new pit at Springwell in 1821, and as this was about five miles from the point they had decided upon to ship the coal, they embarked upon a scheme for a railway from the new pit to the River Tyne, and to employ several of Stephenson's steam locomotives upon the level portion of the line. At the same time it was decided to carry the line over the high ridge to Mount Moor pit, now that steam power was available for rope haulage, (a rival firm had surmounted the difficulties attending the crossing of the ridge in 1809) and to abandon the wagonway to the Wear.

As previously mentioned, it was intended to use steam locomotives from the outset, and there is a possibility that the locomotives were ordered from Stephenson, before the locomotives for the Stockton and Darlington Railway in 1824. The locomotives were not ready when the line was first opened, so horses supplied the motive power where required for several months. The first locomotive delivered was *Billy*, (not to be confused with *Puffing Billy* of Wylam fame), and as this locomotive was sent from Springwell to Killingworth in 1863, and was extensively rebuilt, there is quite a possibility that the locomotive *Billy* in the Newcastle Science and Engineering Museum is the identical locomotive, although it is merely labelled "A Killingworth locomotive". The late E. A. Forward expressed his belief that the locomotives were one and the same. The second locomotive delivered later was named *The Bull*, this locomotive was definitely scrapped later on.

The high ground between Springwell and Mount Moor collieries meant that two powered inclines worked by the same steam engine were required: the incline on the Mount Moor side being much shorter than the one on the Springwell side, and as this latter was on a hillside, a self-acting incline operated between the colliery and the "Bank Foot" where the locomotives took over, covering the four miles or so to the staith, where there was another short incline.

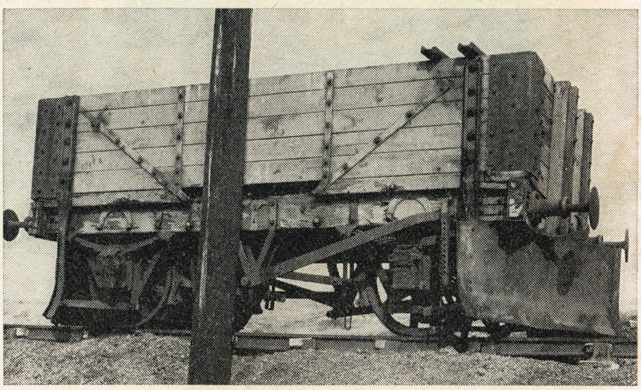
At some time, a passenger service was started from Springwell station to Jarrow, but the earliest timetable traced is dated 1 July 1845; this showed five trains on week days, and four on Sundays. This service continued until 1872, when the North Eastern Railway opened the Pelaw, Jarrow, and South Shields line; from then onwards, the Springwell Railway operated solely as a mineral line.



Loaded wagons ascending the Black Fell side of the Team Valley—crossing an old wagonway.

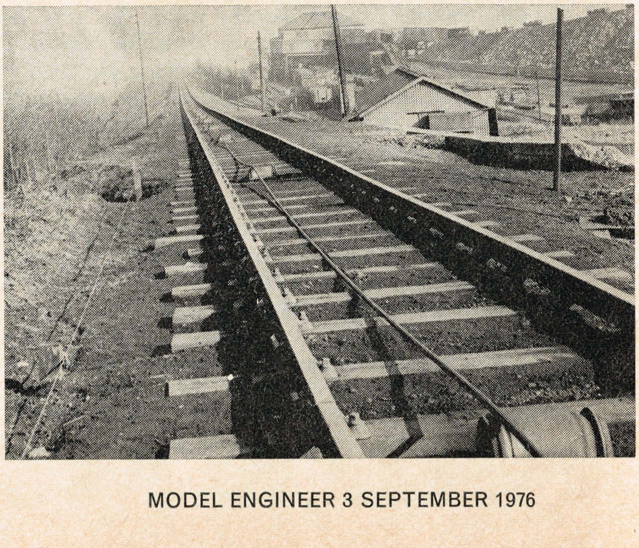
Around 1840, the owners of Kibblesworth Colliery approached the group which was now titled Lord Ravensworth and Partners, suggesting that an extension of the line should be built to their pit. This was agreed to, and the extension of the line was opened on 30 May 1842. As Mount Moor pit was around 400 feet above sea level, and Kibblesworth on the other side of the Team Valley was some 300 feet above sea level, while the floor of the valley was only a few dozen feet above sea level, the magnitude of the undertaking can be grasped. Two steam powered inclines were built, and like the inclines at Blackham's Hill, both these inclines were eventually changed from steam to electric drive.

Marley Hill colliery had been abandoned by the "Allies" in 1815 as being unprofitable to work, but was



An improvised snowplough used on the Bowes line.

Below: The descent from Kibblesworth towards the bottom of the Team Valley.



opened again by George Bowes (a member of Lord Ravensworth and Partners), who formed a separate company in 1841, and sank a new shaft; in 1847 he formed the firm of John Bowes and Partners to take the Marley Hill concern over. Later in 1850, they took over Springwell colliery and railway; in the same year they took over Hobson colliery which was connected to Marley Hill by wagonway. In 1852 the Kibblesworth colliery, and the railway extension from Mount Moor was purchased. In 1854 Andrews House colliery which was close to Marley Hill became their property, also Greencroft colliery in the same year. Now this amounted to their owning two distinct groups of collieries, the Western, which was served by the Tanfield line, and the Eastern served by the Springwell and extensions line, and great annoyance and loss was being experienced in the delay in forwarding loaded wagons to their staith at Jarrow, and the return of the empty wagons to the collieries concerned. As Marley Hill was only some two miles distant from Kibblesworth, it was decided to put in a connecting rail link between the two systems. Here again, this meant another incline to surmount the high ground at Birkheads; this brought the line up to some 550 feet above sea level, and as the fall was with the load, a self-acting incline some mile and a half long was constructed. The building of this rail link took place in 1854, and with its completion, all the coal from the Western group of collieries passed direct to the staith without the delay of having to be shunted around on the Tanfield line, which hereby lost more than half its tonnage carried.

A new colliery was sunk at Dipton, and the line was extended over the old wagonway bed which had previously served this area, thus the line attained a height of over 800 feet above sea level, and a length of 15 miles. The title of Pontop and Jarrow Railway was then bestowed upon it, and in 1932 the line was given the title of "The Bowes Railway"; in 1947 the line was transferred to the ownership of the National Coal Board.

Finally, I would remind those interested in the old railways, that an excellent history of the Bowes Railway by Colin Mountford M.A. was published in 1966 by the Birmingham Locomotive Club, (Industrial Locomotive Information Section), and that a new and enlarged edition by the same author is expected. Some people have remarked on the title, "Pontop and Jarrow", saying that it did not reach Pontop, but I think, as the old wagonway they relaid with standard gauge metals originally served the "Pike Pit", and as it was originally intended to relay the line to this pit again, the title would be quite justified.

PISTON RINGS

SIR,—I was very interested indeed to read Prof. D. H. Chaddock's article on Piston Rings (page 665) and much appreciated the notice he took of my 10 cc. S.V. engine (page 125).

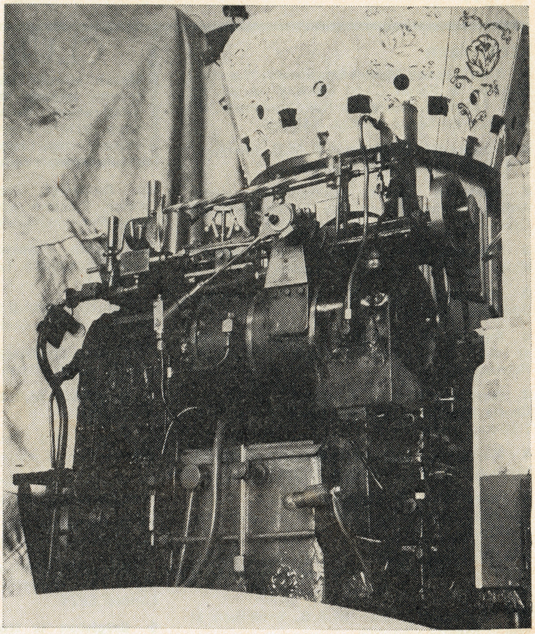
In answer to his query—my engine is 25.2 mm. bore by 19 mm. stroke (9.48 cc.), the piston rings finally being D/21 thick. Next time they will be nearer D/30.

As to splitting a piston ring, it seems to me that expansion over a taper mandrel must indeed cause the ring to break at its weakest point, but surely a well made ring is nearly homogeneous (uniform strength) and its "weakest" point must be very close to the strength of the next weakest point so this, or these, "nearly as weak" points may well be left in a condition where they have been strained just short of breakage. Would this not leave them in an unsafe condition? The "sharp tap" method I used was thought to avoid this possible danger.

The cylinder head of my engine is indeed of the "Ricardo" type mentioned by Prof. Chaddock but the sparking plug (photo on page 125) is at an angle between the valves. This is because the head is water cooled and I wanted a water space over the valves and also because a trial had shown that the long-nose sparking plug I had, together with the need for adequate space for valve lift, would have led to a very deep space over the exhaust valve and my aim was to keep the combustion space as small as possible in search of a reasonable compression ratio.

I look forward to further contributions on I.C. engines by Prof. Chaddock, Mr. L. C. Mason and others.

Isle of Man L. A. Sullivan



The centre engine of the Gallopers built by Mr. R. Taylor and his father in 1937; it is still running today. See letter, page 718, 16 July issue.

"SIMPLEX" RALLY

The Rally for owners of 5 in. gauge "Simplex" locomotives being organised by the Stafford and District M.E.S. has been postponed to Sunday, 19 September. Readers interested should contact Mr. D. A. Amey, "Windward", Boat Lane, Weston, Near Stafford.

CLUB NEWS

Exhibition at Cleethorpes

An exhibition is to be held in the Cleethorpes Memorial Hall on 24–26 September inclusive. The Grimsby & Cleethorpes Model Engineering Society is exhibiting. This Society now has a new ground level track, and sidings and steaming bays are under construction. The Secretary, Mr. R. F. Jackson, has recently moved, his new address being 259 Hainton Avenue, Grimsby, South Humberside.

Birmingham S.M.E.

The Birmingham Society of Model Engineers held locomotive trials on 16 May. Mr. A. Ruston proved to be the winner with his 5 in. gauge L.M.S. 4-4-0; his coal per db.hp.hour figure was the excellent one of 5.2 lb. Second was P. Wardle with his *Nigel Gresley* 2-8-0, third was B. Hares driving his Midland "single" *Princess of Wales*. A. Burrows came in 4th with his $3\frac{1}{2}$ in. gauge "Atlantic", 5th was David Piddington driving his $3\frac{1}{2}$ in. gauge 4-4-0, and 6th was W. Hunt ($3\frac{1}{2}$ in. gauge *Great Northern*). P. Evans (5 in. gauge *Pansy*) unfortunately had to retire.

Secretary: C. Kay, 7 Rowbrook Close, Mayors Green, Shirley, B90 1EJ.

Exhibition in Uckfield

The Uckfield Model Railway Club is holding a small model engineering exhibition at the Alma Hall, Framfield Road, Uckfield, on 18–19 September. The Club has a live steam section and members would like to meet any model engineers in the area who might be interested in the building of a $3\frac{1}{2}/5/7\frac{1}{4}$ in. gauge track. They should contact Mr. L. R. Foster, Glass Castle, Eastbourne Road, Uckfield, Sussex.

News from Malden

The Malden & Dist. Society of Model Engineers have had some very successful track days so far this year. On 11 July, a party of members collected a 30 lever signalbox frame from New Cross Yard, which is to be placed in the new signalbox when completed.

At the 1976 locomotive trials, the winner was T. Rouse, with I. Proctor second, J. Snowdon third, and M. Gibbs fourth.

Secretary: R. S. Edwards, Garden House, Southborough Road, Surbiton, Surrey.

Change at Hastings

There has been a change of Secretary at the Hastings Society of Model Engineers; the new officer is Mr. B. Budden, 146 Hughenden Road, Hastings, Sussex. The Society meets on the first Tuesday of each month at the track at Essenden Road, St. Leonards, and runs on $3\frac{1}{2}/5$ in. gauge ground level continuous track on Saturday afternoons. New members and visitors are always welcome.

CLUB DIARY

Dates should be sent at least five weeks before the event to ensure publication. Please state venue and time. While every care is taken, we cannot accept responsibility for errors.

SEPTEMBER

3 East Sussex Model Engineers. "London, Brighton & South Coast Railway" a talk by A. C. Perryman. Mercatoria Hall, Mercatoria, St Leonards-on-Sea, E. Sussex. 7.45 p.m.

3 Stockport & District S.M.E. Members' and Wives' Track Social Evening.

3 Romford M.E.C. Competition Night. Ardleigh House Community Centre, Ardleigh Green Road, Hornchurch, Essex. 8 p.m.

3 Winchester M.E.S. Slide Quiz—members slides. 36 Bramshaw Close, Harestock.

3 Rochdale S.M.E.E. General Meeting. Springfield. 8 p.m.

4 Peterborough S.M.E.E. Public Running at club track, Lincoln Road, Werrington, Peterborough.

4 Northolt M.R.C. Exhibition. Community Centre, The Manor House, Northolt Village, from 1.30 p.m. to 6 p.m.

4 Northern Ireland M.E.S. Trackside Meeting. Transport Museum, Cultra.

4 Ickenham & District S.M.E. Public Running. Rear of Coach and Horses, Ickenham. 2 to 6 p.m.

4/5 Tyneside S.M.E.E. Open Days. Exhibition Park Track, Newcastle-upon-Tyne. All night running—All welcome.

4/5 Cannock Chase M.E.S. Exhibition at Forum Theatre, Cannock.

4/5 National Traction Engine Club. Hinckley Steam Display. Hinckley, Leicester.

4/5 National Traction Engine Club. Brill Steam Rally.

4/5 National Traction Engine Club. Selwood Vintage Farm Work, Beckington, Frome, Somerset.

4/5 National Traction Engine Club. Worthing Group Autumn Rally.

4/5 Guildford M.E.S. Track event at Guildford Town Show.

4/5 National Traction Engine Club. Stonehouse Model and Engine Show '76. Oldends Lane, Stonehouse, Glos.

4/5 National Traction Engine Club. Cornish Traction Engine Preservation Club, Wheal Honey, Liskeard, Cornwall.

4/5 Fylde Tramway Society. Transport Models' Exhibition. Lecture Hall, Queen Street, Blackpool.

5 Bristol S.M.E.E. Open Day—Visitors welcome. Ashton Court Track, Bristol.

5 Sutton Coldfield & North Birmingham M.E.S. Sunday Open Day at Lea Marston.

5 Guildford M.E.S. Running day for members and friends.

5 Hull S.M.E. Open Day at the Goddard Avenue Track. Commence 1 p.m.

5 Norwich & District S.M.E. Public Running. Eaton Park Track.

5 Chelmsford S.M.E. Public Running. Waterhouse Lane. 2.30 p.m.

4 S.M.E.E. Talk—classical guitar making—Mr. G. Love. Marshall House, 28 Wanless Road, London SE24.

5 Brighton & Hove S.M.L.E. Harlington Loco Society Visitors' Day.

5 Harlington Locomotive Society. Open Invitation to other clubs to run at Harlington—not open to public.

5 Rugby M.E.S. Members' Running Day. Hillmorton Community Centre, Hillmorton Road, Rugby.

5 Harrow & Wembley S.M.E. Pondside Meeting. West Harrow Recreation Ground. 10.45 a.m.

5 Welling & District M.E.S. Track Run South Eastern Gas Board, Families Day, Horn Lane, Greenwich, SE10.

6 Worthing & District S.M.E. 8 mm. film night. Broadwater Hall. 7.30 p.m.

6 City of Leeds S.M.E.E. Next year's programme. Salem Congregational Church, Hunslet Road, Leeds 10. 7.30 p.m.

7 Sutton Coldfield & North Birmingham M.E.S. Talk on Tal-y-llyn Railway—R. Pearce.

8 Sutton Coldfield Railway Society. Fun and games with signalling. Wylde Green Library, Emscote Drive, Little Green Lanes, off Birmingham Road, Sutton Coldfield. 7.30 for 8.15 p.m.

8 Harrow & Wembley S.M.E. Traction & General Meeting. B.R. Sports Pavilion, Headstone Lane. 7.45 p.m.

8 Cannock Chase M.E.S. Talk by P. Booth "Welsh Highland Railway". Lea Hall Club, Sandy Lane, Rugeley. 7.30 p.m.

8 Grimsby & Cleethorpes M.E.S. General meeting and talk by R. J. Bray on track signalling Findus Sports Club, Cleethorpes.

9 Hull S.M.E. Talk on Flying Exploits with G. Davidson. Trades & Labour Club, Room 3, Beverley Road. 7.45 p.m.

11 Southern Federation of Model Engineering Societies. Autumn Rally at Brighton Hove Society track, Hove Park, Brighton.

11 Southampton & District S.M.E. Open Day Riverside Park. 10 a.m.

11 Harrow & Wembley S.M.E. Southern Fed. Rally, Cambridge.

11 Welling & District M.E.S. Track Run. Greenwich Show, Sutcliffe Park, Eltham.

11 S.M.E.E. Disposal Sale. Marshall House, 28 Wanless Road, London SE24.

11 North London S.M.E. Southern Federation Rally—Brighton.

11/12 National Traction Engine Club. Haddenham Steam Rally. Ely, Cambs.

11/12 National Traction Engine Club. Cumbria Steam Gathering, Kendal.

11/12 National Traction Engine Club. Steam Gathering. Oakes Park, Norton, Sheffield.

MODEL ENGINEER HOT AIR ENGINE COMPETITION

A COMPETITION to encourage the design and building of hot air engines will be held at the 1977 Model Engineer Exhibition. Prizes have been generously donated by Mr. A. N. Clark, of Ryde, Isle of Wight, and Professor D. H. Chaddock, C.B.E., has kindly consented to act as Judge.

The only conditions are as follows:

1. The hot air engine entered must be the unaided work of the competitor.
2. No entry will be accepted from a professional model maker.
3. The decision of the Judge/s shall be final.
4. The swept volume of the working cylinder/s shall not exceed 5 c.c.
5. The power output of the engine will be measured by a friction brake with a lever arm and weights.
6. Speed measurement will be by revolution counter and stop watch.
7. All engines entered must have a standard output shaft 5/32 in. dia. x $\frac{3}{4}$ in. (approx.) long.
8. Competitors will have the option to run their engines themselves, under the scrutiny of the Judge/s.
9. Competitors should submit with their entry notes for the Judge/s regarding lubrication, firing, warm-up procedure, minimum and maximum revs. at which the engine should be run.
10. The duration of each run shall be left to the discretion of the Judge/s.
11. Winners will be required to submit details, a photograph and drawings of their engines for publication in *M.E.*
12. Although every care will be taken, the organisers cannot be held responsible for any accidental damage to the engines.
13. Details of entries must be sent to the Exhibition Manager, M.A.P. Ltd., not later than 1 December 1976.

PRIZES:

1. A first prize of £50 would be awarded for the hot air engine developing the highest horsepower.
2. A second prize of £25 would be awarded for the engine developing the second highest horsepower.
3. There would be a consolation prize of £10 for the engine (other than those awarded the 1st and 2nd prizes), which displayed the highest standard of workmanship.
4. There would be a second consolation prize of £10 for the engine which displayed the most original design work.

11/12 National Traction Engine Club. Tonbridge Steam Engine Rally. Leigh, Tonbridge, Kent.

11/12 Malden & District S.M.E. 40th Anniversary Exhibition at Thames Ditton.

11/12 Crofton Beam Engines. Open to the Public. Nr. Great Bedwyn, Beds.

12 Bristol S.M.E.E. Public passenger carrying day. Ashton Court Track, Bristol.

12 Kings Lynn & District S.M.E. Portable track—Dow Chemicals Open Day. 2–6 p.m.

12 Guildford M.E.S. Visit by coach to Cranmore Railway Museum.

12 Keighley & District M.E.S. Open Day. St. Georges Playing Fields, Marley, Keighley, W. Yorks. Refreshments and car parking available.

12 Brighton & Hove S.M.L.E. Display at Vintage Day, Bluebell Railway.

12 Harlington Locomotive Society. Public Open Day. High Street, Harlington, Middx.

12 North London S.M.E. Second Open Day—Colney Heath.

12 Northampton S.M.E. The Society's miniature steam railway is open to the Public. Delapre Park, London Road, Northampton. 2.30 to 5 p.m.

12 Chelmsford S.M.E. Public Running, Waterhouse Lane. 2.30 p.m.

12 Bracknell Railway Society. Public Running Day. Jocks Lane, Bracknell. 3 p.m. to 6 p.m.

12 Peterborough S.M.E.E. Invitation Running at Club track. Lincoln Road, Werrington, Peterborough. All friends and members of other societies welcome. 10.30 a.m,

13 Bedford M.E.S. Tool Sale. Clubhouse, Wilstead. 7.30 p.m.

13 King's Lynn & District S.M.E. Monthly Meeting—St. James School, London Road, King's Lynn—'Steam Locos'.

13 Peterborough S.M.E.E. Club meeting. Club house, Lincoln Road, Werrington, Peterborough.

13 Wirral M.E.S. Illustrated talks by Mr. J. France and Dr. B. Kohler—"South Africa and Railways in East Africa".

15 Harrow & Wembley S.M.E. Berlin's Rail Transport by Mike Ballinger (slides). Wylde Green Library, Emscote Drive, Little Green Lanes, off Birmingham Road, Sutton Coldfield. 7.30 for 8.15 p.m.

16 Nottingham S.M.E.E. Ladies' Evening—Mr. D. Cope. The Friends' Meeting House, Clarendon Street, Nottingham. 7.30 p.m.

16 Leyland, Preston & District S.M.E. Meeting. Roebuck Hotel, Leyland Cross, Leyland, Lancs. 8 p.m.

17 East Sussex Model Engineers. Pond Night—Boating Lake, Alexandra Park, Hastings. 7.30 p.m.

17 Romford M.E.C. Sievert Equipment—Mr. Ilett, Kenneth Johns Ltd. Ardleigh House Community Centre, Ardleigh Green Rd., Hornchurch, Essex. 8 p.m

17 Stockport & District S.M.E. Talk by Mr. G. S. Snowball on his visit to South Africa. Wellington House, 324 Wellington Road North, Stockport. 8 p.m.

17 Rochdale S.M.E.E. General Meeting. Technical College. 7.30 p.m.

18 S.M.E.E. Informal Meeting—Marine Topics. Marshall House, 28 Wanless Road, London SE24.

18 Harrow & Wembley S.M.E. Night Run. B.R. Sports Pavilion, Headstone Lane. 7.45 p.m.

18 Sheffield & Dist. S.M.E.E. Open day. Brincliffe Track, Omega Restaurant, Chelsea Rd., Sheffield. Boiler test certs. required. 1.30 p.m.–6.30 p.m

18 Southampton & District S.M.E. Visit to Beech Hurst Track.

18 Brighton & Hove S.M.L.E. Special train from Worthing to Kidderminster for SVR.

18 Wigan & District M.E.S. Meeting. Co-operative Guild Room, Thompson Street, Whelley. 7.15 p.m.

18/19 National Traction Engine Club. Roxton Park Traction Engine Rally. Nr. Bedford.

18/19 Golden Gate Live Steamers. Fall Run. Oakland, Ca.

18/19 National Traction Engine Club. Ironbridge, Shropshire.

19 Guildford M.E.S. Public Open Afternoon. HQ, Stoke Park 2–6 p.m

POSTBAG
The Editor, Model Engineer, Box 35 Bridge Street, Hemel Hempstead.

The Editor welcomes letters for these columns. He will give a Book Voucher for £3.00 for the letter which, in his opinion, is the most interesting published each month. Pictures, especially of models, are also welcomed. Letters may be condensed or edited.

Metric System

Sir,—So at last the pages of this venerable and respected journal have succumbed to the rot of metrication.

The doubtful honour of introducing the system falls to Mr. Hughes who, being a member of the teaching profession, I hasten to say, is quite blameless in using a system that he has been obliged to pump into children for some years. My ensuing remarks must not be taken in any way as criticism of him or his excellent new series on the Marshall portable.

I too am (unwillingly) concerned with the metric system in my shop, serving litres of paint and metres of timber. I also have two children aged 9 and 13 and can therefore write this letter as a representative of those upon which the metric system has been foisted, rather than one who does the foisting.

One comment I must make regarding the school leavers knowing only the metric system whom Mr. Hughes mentions. This surely is a condemnation of the quality of our educational methods of today. Like it or not, the Imperial system will be around for many years to come and it is still essential for a good working knowledge of it to survive in industry. There is no excuse for complete ignorance of the Imperial system and perhaps this is where model engineering—for those youngsters who take up the delectable hobby—can have a beneficial effect in showing them the advantages of using inches thus helping to ensure that they do not have a "blind spot" in their knowledge when out in the world earning a living.

A general discussion of the two systems would be inappropriate here, my concern being the relevancy of the application of the metric system to model engineering.

I submit that it is quite irrelevant to set out to make a model in (say) 1 in. scale and then proceed to multiply everything by 25.4 mm. Similarly it is just as wrong to call 12 in. in 2 in. scale 50 mm. Awkward numbers to multiply with or convenient numbers to approximate to are not good enough. Dimensions in inches can only be scaled in inches and I am afraid that anyone who converts either way will not have an accurate model.

Admittedly, dual dimensions give a choice to the constructor, but the resultant drawings can only be confusing to the eye, not to mention the extra work of converting every dimension from the draughtsman's and author's point of view resulting in cluttered text and drawings.

It was a sad day when metrication was introduced into the United Kingdom, but I suppose we are now stuck with it thanks to our politicians. America has so far resisted metrication. Perhaps they will have the good sense to go on doing so and not join in the metrication melee, which is helping to reduce us as a nation to one of a number.

Leave the metric system out of model engineering unless the prototype was originally metric-built. Most steam models are and always will be made to prototypes produced in a far more enterprising era than ours. Let us at least honour those days by using the dimensions that were perfectly acceptable then and are just as acceptable now.

With the Editor's permission, I would like to suggest that a survey (perhaps by letter) be made of the general feeling among model engineers young, old and middling (like myself) about the use of the metric system in model engineering.

Personally, I say to blazes with what we are *told* is good for us—model engineering is one thing that can do without being metricated.

Tilehurst — Colin R. Tyler

Metric System

Sir,—I feel I really must take issue with Mr. W. Moor on a number of points in his recent article "Two Useful Tools". What follows is intended as constructive criticism and will, I hope, be accepted as such.

Firstly, he appears to condemn Mr. Mackintosh for describing a design he hadn't actually made. What is wrong with this I cannot see, as it is done regularly by reputable firms in proposals to their customers. It is not uncommon for such articles to be ordered "off the drawing board", as one need not see the hardware to judge the soundness of a design or indeed predict its performance.

Secondly, I cannot but disapprove of his suggestion that *Model Engineer* should become one more tool in the hands of his metric-advocating Ministry masters. Due to his not being in close contact with industry, Mr. Moor is probably unaware that a considerable proportion of his pupils will have to unlearn metrics and learn Imperial before they are any use to an employer. Not all industries are going fully metric (apart from those whose Ministry customers insist on it), and the process of change appears to be rapidly slowing down. Furthermore, I get the impression that Mr. Moor is unaware that no-one ever willingly changed to metrics (maybe there is an exception somewhere) and probably never will.

Thirdly, if Mr. Moor is really one of those (rare) convinced metric advocates, he should be consistent about it. Unfortunately, he mixes the two systems and gives inaccurate conversions such as 13 mm. = $\frac{1}{2}$ in. (13 mm. = 0.5118 in.).

Finally, may I say that his scribing block design is excellent and I shall certainly make one. It will not be metric, but will be none the worse for that so please, Mr. Moor, keep your propaganda for the place where you are paid to use it. The pages of *Model Engineer* are not intended for this sort of thing.

Waltham Chase, Southampton — G. Read

Metric System

Sir,—I wonder if, through "Postbag", I can raise the question of metrication again. The current article by Mr. W. Moor is very interesting, particularly about pushing metrication in schools. It really is time *Model Engineer* went metric, because if the hobby in its present form is to attract "new blood" then the existing system of using fractional dimensions with metric drawing symbols must change.

In view of the fact that schools today, certainly in this area, are totally metric, what is going to happen in 2 or 3 years time when these children leave school: utter confusion. What are these strange symbols, feet and inches? Even now my 10-year-old son is confused, and he takes a keen interest in model engineering.

Material is changing, drills and tools are changing, so sooner or later dimensioning of components must change, so why not now? If it is possible why not use the system used in many industries during changeover, that of double dimensioning?

For example 6,3 ($\frac{1}{4}$ in. dia.). I know it requires more space and sometimes causes confusion but at least it would be a start. The views of other contributors would be most interesting particularly those with fractional indexes on their machine tools.

Tupsley, Hereford J. G. Arrowsmith

The Rivett Lathe

SIR,—I was very interested to see the article by Eric Watson on the Rivett Lathe (2.7.76 p.647), he is a very lucky person to possess such a machine.

Regarding his query wishing to know more about the company who made these machines, I would direct his attention to a letter by me in *M.E.* for 2 January last p. 43.

Apparently from the catalogue he has, no information is given regarding the taper used on the centres. I cannot find anything either, but as he says it is between Nos. 1 & 2 Morse Tapers it may be what was known as the Jarno taper; this was used by some American machine tool companies many years ago including the Pratt & Whitney and Norton Grinding Co's. I give below more details of this particular standard for this taper, so possibly Mr. Watson will be able to check up and see if his centres do conform to the Jarno taper.

In this system the taper of which is 0.6 inch per foot included angle, the number of the taper is the key by which all the dimensions are immediately determined without the necessity even of referring to a set of tables. That is, the number of the taper is the number of tenths of an inch in diameter at the small end, the number of eighths of an inch at the large end, and the number of halves of an inch in length. For example: the No. 6 taper is six eighths ($\frac{3}{4}$) inch diameter at large end, six tenths (6/10) diameter at the small end and six halves (3 inches) in length.

There were twenty tapers in the complete table running from No. 1 to 20 and the taper in this system which comes between Nos. 1 and 2 Morse is No. 5 the dimensions of which are: Large end .625 in., Small end .50 in. and Length 2.5 in.

I trust the above information will be of interest and of some help to Mr. Watson.

Wembley J. H. Davis

Old Lathes

SIR,—Looking through some of my back copies of *M.E.* the other day I came across the article by P. J. Banks on his old MASSEY lathe (Copy No. 3522, October 1975). Though I cannot throw any more light on this particular machine than has already been done by Messrs. Roberts and Handel (November 1975), the following may be of some interest to Mr. Banks and others.

At a recent local auction sale I picked up a batch of old "Electrical" books, amongst which I found two, decidedly non-electrical, which are now amongst some of my most prized literature. One is entitled "Turning Lathes", edited by James Lukin and published by the Britannia Company of Colchester in 1894. This book contains a wealth of information on the "Old" methods of producing turned work, and has descriptions of several attachments which were supplied by the Britannia Company at that time, and which, to my knowledge at least, have since been forgotten. Some of these could have applications in the modern small workshop, particularly some of the Ornamental Turning attachments. The second half of this work consists of a complete catalogue of the machine tools produced by the Company, and it is interesting to note the striking resemblance between many of the smaller lathes illustrated and Mr. Banks'. Even the wording of the Manufacturers' nameplate is similar, though in the case of the Britannia lathes, this was cast into the front of the bed, suggesting to me, at any rate, that Mr. Banks' lathe is rather older—possibly about the mid-1800's? My second book is entitled "Ornamental Lathework for Amateurs", written by "C.H.C." and published by—wait for it—Percival Marshall. It is undated, but must have been produced about 1914 as it contains an advertisement for back copies of *M.E.* up to December 1913—an advertisement I was very tempted to answer! The front flysheet of this book carries an advertisement for RELMAC lathes, again very similar to Mr. Banks' in appearance, and priced at five pounds ten shillings for the bench model, and eight pounds ten shillings complete with stand and treadle gear. Those were indeed the days, though unfortunately before my time! This book again includes many items of interest to the model engineer—including instructions for making elliptical and other chucks—a request I seem to remember from further in the past.

I hope, in due course, and subject to Editorial approval, to bring some of the information in these books up to date a little and submit it for publication, though my first priority at present is the rebuilding of my own lathe —a Grayson of indeterminate age and damaged headstock. I am intending to utilise an old Ford gearbox as the basis of a replacement headstock for this, a project which may in itself provide the meat of another article!

In the meantime, if any readers would care to borrow either of the books mentioned, I would be happy to loan them for a short period as they will be of little practical use to me until my workshop is again in operating order. I must emphasise, however, that they are *not* for sale!

Saltash S. J. Hunt, Lieut. R.N

Drummond Lathes

SIR,—I was very interested to read Mr. H. T. Trotman's letter in your issue No. 35H concerning round bed lathes.

The serial number of his Drummond 4 in. is 2256, mine is 57 (yes, all the varieties!). It was bought by my father when they were first produced by Drummond in 1908, and is still in use by me today.

It has the original split bronze bearings to the headstock spindle but was fitted with a new spindle by Drummonds in 1922, to accommodate size "A" split collets. Otherwise, no other structural alteration has been effected, though back gear, and tumble reverse are fitted (both homemade of course).

Mr. Trotman's estimate of the original cost of this lathe is excessive—it was only £5! Not 5 guineas.

I wonder if there could be found any other lathe in the world, comparable in cost which is still in daily use after two-thirds of a century?

Argyll R. M. Stewart

Paints

SIR,—May we through your "Postbag" column, correct a statement made in the excellent article by B. G. Markham, on his $3\frac{1}{2}$ in. gauge *Ella*.

In the paragraphs on Livery, Mr. Markham indicates that the thinners for our S4 Clear Self Etch Primer is Xylene. If straight Xylene is used in an attempt to thin the Etch Primer, disastrous results will occur. The primer will take on the consistency of "Evo-stik" and will be extremely difficult to clear from brushes or the passageways of air brushes or other spray equipment. Whilst the basis of this solvent is Xylene, there are a number of other chemicals added to prevent this occurrence which is called "livering". The correct thinners are S5 Clear Etch Primer thinners. We would like to stress that where a manufacturer recommends a special solvent (this applies to all paint manufacturers, not just ourselves), it is of the utmost importance that substitute solvents are not used, to ensure complete compatibility between paint and thinners.

We note that Mr. Markham rubbed all his brass components with fine wet-and-dry paper prior to applying the Etch Primer, as well as wiping over the parts with thinners to clean them. Provided the parts to be primed are not bruised or otherwise disfigured, it is only necessary to wipe the plates clean with solvent. This will prevent the possibility of fine particles of metal lodging in the wet-and-dry, and adding deeper scratches to the surface being cleaned.

In closing, Mr. Markham is to be congratulated on producing such a fine example of an unusual prototype.

Cheltenham
R. G. Shephard,
(Director),
Precision Paints Co.

Gear Cutting

Sir,—In *Model Engineer* dated 19 March 1976, p. 282, Mr. T. D. Jacobs mentioned the problem of setting up a gear train to give the ratio of 1 to 1.0026 and gave two approximate solutions. With such ratios, close to unity, there is in fact a formal method of deriving the best possible train, the accuracy of which will in general improve with an increase in the numbers of teeth in the wheels. The method makes use of the fact that if we take any three consecutive numbers, then the square of the middle number is always one greater than the product of the first and third. To make use of this identity, write down the given ratio. Then divide it by the fractional part and take the square root of this number, which will give the number of teeth in the middle gear. The other two have respectively one more and one less tooth. Using Mr. Jacob's example:

Ratio required = 1.0026
Fractional part = 0.0026
1.0026 ÷ 0.0026 = 385.6
Square root = 19.64

Clearly we cannot have fractional teeth so choose the nearest integer, 20. The other gears are 19 and 21 and the train becomes 20 x 20/19 x 21 = 1.0025.

If this is not close enough, proceed as follows. Write down the number 385.6 and underneath this write down 384.6 (1 less than the first number). We must now do some intelligent guesswork. Write down a series of fractions with numerators around 385 and with denominators always one less than the numerator. By inspection, pick out a pair which will factorise with reasonable numbers, as under:

$$\frac{384}{383};\ \frac{385}{384};\ \frac{385.6}{384.6};\ \frac{386}{385};\ \frac{387}{386}\ \ldots\ \ldots\ \ldots$$

$$\text{now}\ \frac{385}{384} = \frac{35}{32} \times \frac{11}{12} = \frac{35}{32} \times \frac{55}{60} = 1.002604$$

The error is less than 4 parts in 1 million, using a simple gear train with only one special wheel. If standard gears must be used, an equivalent compound train is: 25 x 35 x 55/20 x 40 x 60 = 1.002604.

In a later issue, *Model Engineer* 7 May 1976, p. 458, Mr. C. H. Baker posed a question on cutting module pitch screws which involve the ratio π. This was answered by Prof. Chaddock and while I agree that, in practice, sufficient accuracy may be achieved by taking $\pi = 22/7$, it may be of interest to list some gear trains which give much closer approximations.

First, to a very high order of accuracy $\pi = 3.1415926536$ and $1/\pi = 0.3183098862$. Commonly used approximations with errors expressed in terms of the true value are given below. Positive signs means that the approximation is larger than the true value.

22/7; + 1 in 2484.476064
3.1416; + 1 in 427660.3122
355/113; + 1 in 11810498.7

The second and third lines give rise to awkward gear trains with large wheels; the first is considerably in error. A useful practical train to cut a 20 d.p. worm using a leadscrew with 8 t.p.i. is 29 x 65/30 x 50. The error is 1 part in 42446.62337. It is about 10 times less accurate than Mr. Baker's toolroom train but is 17 times better than that using $\pi = 22/7$.

All the gears are small and only one special is required. Two gear trains of quite extraordinary accuracy are:

$$\frac{68}{31} \times \frac{143}{93} \times \frac{163}{175} = 3.141592587$$

Error = 1 in 46 889 442.6

$$\frac{41}{25} \times \frac{48}{25} \times \frac{51}{25} \times \frac{77}{131} \times \frac{109}{131} = 3.141592677$$

Error = 1 in 136 590 985.

Both these are of course absurdly impracticable but it is of interest to note that the last one gives an accumulated pitch error rather less than one thousandth of an inch in a workpiece two miles long!

$$\frac{25}{32} \times \frac{71}{32} \times \frac{105}{107} \times \frac{137}{107} \times \frac{163}{113}\ \text{gives}\ \pi = 3.1415926524$$

This is 1 part in 2617 993 878 less than the true value of π and the error is in fact too small for accurate evaluation on a 1– digit calculator without using a special procedure. In engineering terms the error amounts to less than 0.001 inch in 40 miles.

Cheltenham, Glos.
F. Butler

Statuette

Sir,—If you could spare me a few lines in "Postbag" I can definitely clear up the Vulcan Statuette query. Vulcan cars were made at Vulcan Motor Works, Crossens, Southport, until the works changed hands and became an engineering works, also now defunct. A very good friend of mine, long retired and a very skilful and inventive engineer I might add, was apprenticed to Vulcan Motor Works from 1916 right through until the finish of the engineering works after the Second World War and as soon as he saw my photograph in *Model Engineer* recognised the statuette as the car mascot immediately. So Mr. T. A. Simpson is correct in his assumption that the statuette is a mounted car mascot.

Southport
W. H. Cook

Parting off

Sir,—Having just received my latest copy of *Model Engineer*, 5 March 1976, I note where some of your readers are having difficulty in parting off.

I have been using pieces of power hacksaw blades for years, and have never had any difficulty in parting off. All I do is to grind a piece of blade to ⅝ width, and grind a front rake. I then clamp this between a piece of square steel (⅝), split down the middle. While using the tool for parting off I keep the cut flooded with cutting oil.

Hoping this may be of some use to your readers.

New Zealand
J. J. Sargent

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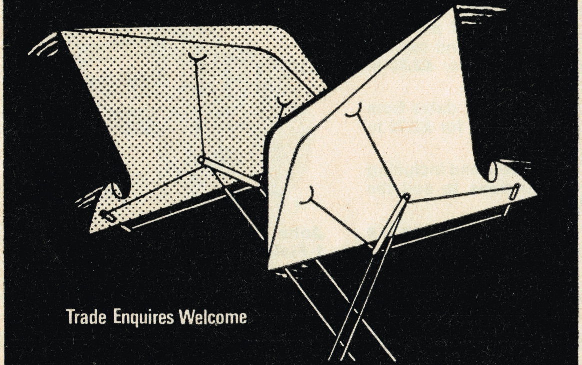

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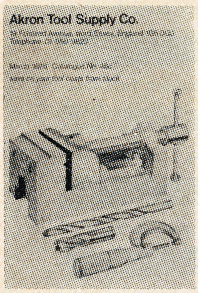

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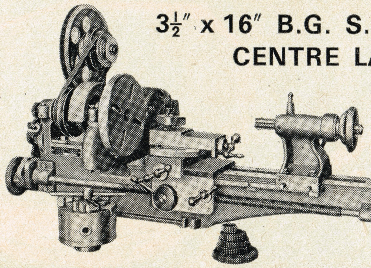

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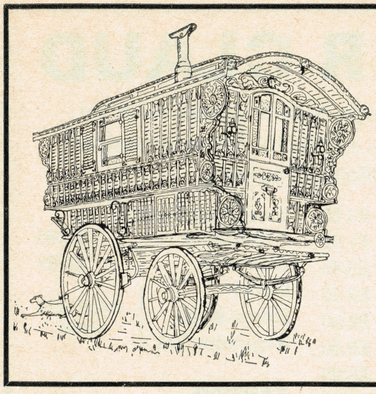

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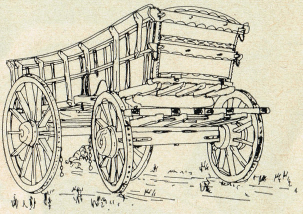

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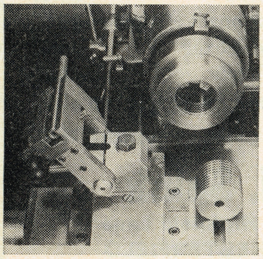

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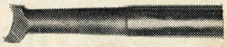

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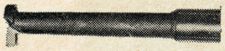

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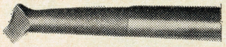

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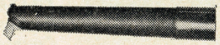

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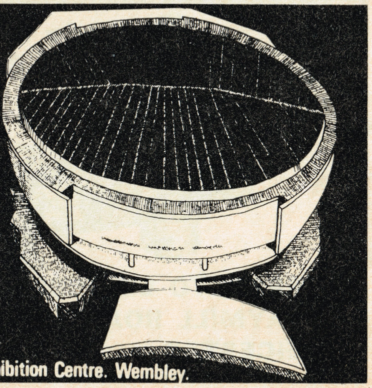

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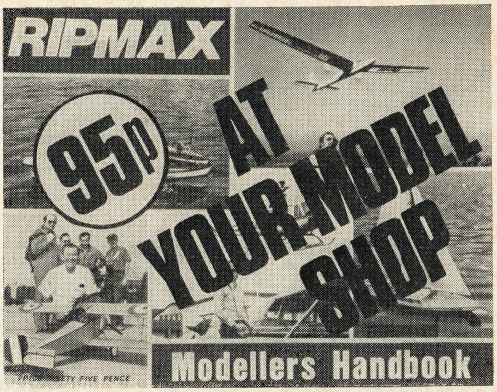

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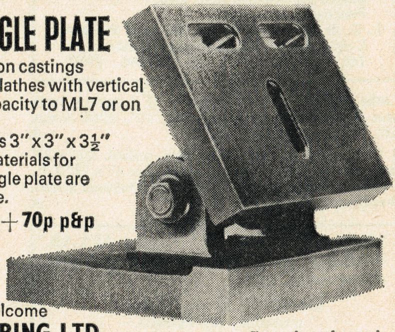

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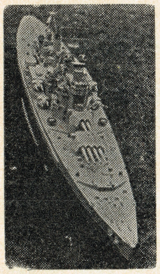

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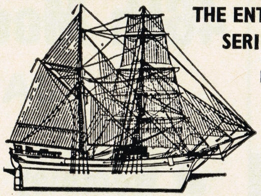

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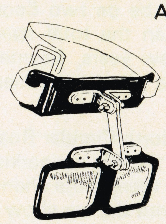

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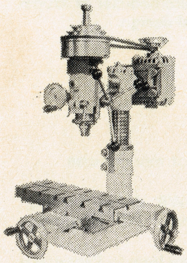

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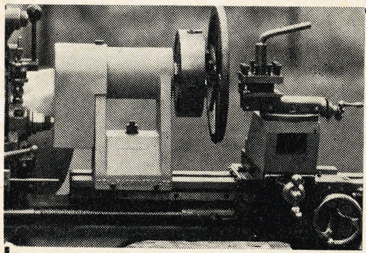

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SEPTEMBER 1976

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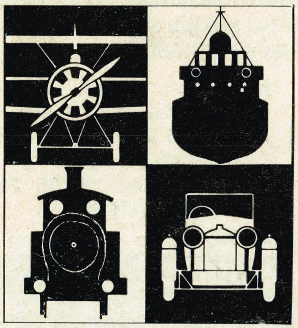

46th Model Engineer Exhibition

JANUARY 4-15th, 1977

(Not open Sunday)

at Wembley Conference and Exhibition Centre

LOCOMOTIVES, BOATS, AIRCRAFT, TRACTION ENGINES
MILITARIA, WOODWORK, CRAFTS

The 1977 Exhibition moves to the brand new Wembley Conference and Exhibition Centre, right next to Wembley Stadium and the Empire Pool. It will be on two floors, each of which is greater in area than the total space available at our home for the last few years, Seymour Hall, and there will be over 100 trade stands and many society and association displays.

Conveniently situated just off the North Circular Road, between the ends of the M1 and M4, there is car parking for 5,000 cars (or 2,000 coaches) and there is the chance to combine a visit to the Exhibition with the ice show at the Empire Pool or the Christmas show at the new 2,700 seat theatre. Catering facilities are excellent—the Bridge Bar, in the Exhibition, seats 500, and there will be a snack bar and restaurant. Even if twice the numbers of previous years attend on any one day, there should be no real crush.

On the upper floor will be most of the engineering and marine stands and exhibits, including the S.M.E.E. workshop and track, plus a Gem Craft section (popular with the ladies!) while downstairs will be military modelling and wargaming, aircraft, the central display area (electric aircraft, R/C cars and tanks, live steam traction engines, etc., etc.) plus, for the first time, a special Woodworker area, with famous tool suppliers, demonstrations, competition entries etc.

Throughout, demonstrations are planned, including lathework, brazing, milling, and other workshop practices, lapidary, enamelling, wargames, miniature weapon-making, cart making, wood turning and machining, boatbuilding—a real feast of how to do it.

COMPETITION CLASSES

Entries are invited in the following categories:

A	Locomotives. $2\frac{1}{2}$ in. gauge and over.	
A1	Locomotives—to any L.B.S.C. design $2\frac{1}{2}$-5 in. gauge (including steaming).	
B	Locomotives. In gauge 1 and 0.	
BA	Locomotives. In gauges smaller than 0.	
C	Rolling Stock and Accessories. Gauge 1 and 0 or larger.	
CA	Rolling Stock and Accessories. Gauges smaller than 0.	
D	Steam and Motor Ships of any period. (Non-working).	
E	Power Driver Boat Models. (Complete with power plant). Scale or Freelance.	
F	Sailing Ships of any period. (Non-working).	
G	Working Yachts and Sailing Ships.	
H	Hydroplanes and Speedboats.	
I	Miniature. Length of hull not to exceed: 9 in. for $\frac{1}{8}$ in.—1 ft. scale or larger; 10 in. for $\frac{1}{16}$ in. scale; 12 in. for 1/25 in. scale, 15 in. for $\frac{1}{32}$ in. scale. No limit for smaller scales.	
J	General Engineering Models (including stationary and Marine Engines).	working models
K	Internal Combustion Engines.	
L	Mechanically Propelled Road Vehicles (including tractors).	
N	Tools and Workshop Appliances.	
O	Engineering Scale Models (Non-working).	
P	Scenic and Representational Models (including Architecture).	
Q	Horological, Scientific and Optical Apparatus.	
R	General Craftsmanship—not otherwise classified.	
S	For any type of model (other than military) or mechanical work by a junior under the age of 16 by 31 December, 1976.	
AA	Flying models of all types; (a) free flight, (b) control-line and (c) radio control.	
AB	Scale flying models of all types, rubber, glider, power, control-line or radio control.	
AC	Scale non-flying models.	
AF	A piece of radio control equipment built to a design published in Radio Control Models & Electronics, Aeromodeller or Model Boats, from a commercial kit, or of original design.	
MA MB MC MD MJ1 MJ2	Classes covering miniature figures, dioramas, artillery, etc, detailed on official entry form.	

Junior Prize additional in each class with three or more entries. (Under 16 on 31st December, 1976).

Woodworker Section: WA Cabinet making; WB Wood carving; WC Wood turning; WD Musical instruments; WE Marquetry; WF Fretwork, pyrography, miscellaneous

Entries for these classes should use special entry form in September or October 1976 issues of Woodworker magazine. Note that these particular classes are open to both amateur and professional craftsmen.

In addition, there is a competition for hot air engines, a special classification for model boats built from a kit, and a one-subject Colonial 1857-1900 military modelling class. Details of all these in the appropriate magazines and/or on the entry information forms, available after mid-July. Loan (non-competitive) entries will also be considered.

This is *your* exhibition as much as ours, and we hope to have the favour of your full support—lots of models, volunteer stewards/demonstrators etc. to make this first major exhibition at the new venue a resounding success which will further the interests of modellers nationally.

COMPETITION ENTRY CLOSING DATE IS OCTOBER 18th, 1976